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The Inventor of the Drehstrom System. IN another column will be found a letter from Mr. C. E. L. Brown, for some years past the electrician of the Oerlikon Works at Zurich. It is of special interest as bearing on a subject often previously noticed in these columns. Some weeks ago we stated with reference to the long distance transmission of power from Lauffen to Frankfort that the one particular thing undergoing test was not at all the three-phase current system, but the possibility of using enormously high voltages in commercial work. Mr. Brown's letter simply goes to confirm this statement in the most unqualified way, and as the idea of that epoch making experiment originated with him, he certainly is amply qualified to speak with authority on the subject. The final sentence of his letter is one to which we cannot refrain from referring with great satisfaction, as it is an unsolicited and emphatic endorsement of Mr. Nikola Tesla's well founded claims to priority in the use of this particular class of alternating current motors.

The Electrical Census. A STATEMENT of the present position of the Census Office with respect to electrical investigations is given in a letter from Supt. Porter to the Secretary of the Interior, published elsewhere in our columns. His report is a matter for congratulation both to the representatives of electrical industry and particularly to the National Electric Light Association, through whose earnest efforts the continuance of the special electrical census has been made possible. Supt. Porter discontinued all special census investigations on account of lack of sufficient funds to carry on the work properly. So earnest a protest, however, was made by the National Electric Light Association to the President of the United States that the matter was referred again to Mr. Porter by the Secretary of the Interior, with the result that work is now resumed on the electrical census and will be continued so far as the resources of the Census Bureau permit. It is to be hoped that when Congress meets again steps will be taken to have not only the special electrical census continued but in general to make the industrial statistics of the Eleventh Census as complete and reliable as present methods will allow.

Curves of Magnetic Reluctance. MR. A. E. KENNELLY'S paper on magnetic reluctance published elsewhere in this issue is a singularly lucid and suggestive treatment of the modern theories of magnetization. Permeability curves are already familiar in electrical literature, but to plot for various specimens of iron the graphic relation between the magnetic induction and the reciprocal of permeability is somewhat novel. Of course the transformation is an obvious one, but, as frequently happens in scientific work, turning a subject around and looking at an unfamiliar side often suggests things that would scarcely be thought of otherwise. The theory of magnetism has in the last few years received an amount of attention that has resulted in clearing up much of the mystery that used to surround the subject, and bringing many magnetic phenomena within the range of ordinary dynamical laws. The beautiful work of Ewing has been largely responsible for this splendid result and has caused an entire remodeling of the scientific treatment of magnetism. Mr. Kennelly's paper puts many of these modern ideas in simple form and the particular form in which he has shown the curves of magnetization are specially well adapted to illustrate certain somewhat complicated phases of the subject.

Direct Coupled Dynamos. WE have been illustrating recently several direct combinations of engines and dynamos, and their appearance in our pages is an indication of one of the directions now being taken by engineering practice. There is now a very evident inclination to utilize such machines, especially in city stations, where floor space becomes an important consideration. On the whole the arrangement is productive of good results as regards economy, but with this should be taken into consideration some of the disadvantages of the plan. The direct coupled generator and engine in relation to central station work stands in much the same position as the directly belted engines and dynamos that are in general use to-day; they have the advantage of dispensing with the very slight loss incident to the use of belting and of saving space; but have, however, in common with direct belted combinations the disadvantage that an accident, even a trifling one, to either machine puts both out of service, while where large engines are used in connection with counter shafting it becomes possible to run any dynamo or group of dynamos from any engine. Where the single combined units of engine and dynamo are small with reference to the total capacity of the station this objection becomes less serious and consequently it would appear that the best place to use such machines is in the case of large city plants where the saving of space is important and the aggregate horse power is so large as to necessitate the employment of enough machines to reduce to a minimum the inconvenience caused by the crippling of any one of them.

An Electrical Congress for the Chicago Fair. THIS subject has been receiving of late no small amount of attention from American electricians. We trust that some of the plans may be followed out, and that 1893 will see a veritable international congress instead of the sort of gathering hinted at in the title of this note. It is eminently proper that the United States government should take action in the matter of a meeting of electricians of all nationalities, but it is most unfortunate that in thus taking the initiative the managers of the affair left quite out of consideration the only representative body of electrical engineers in this country. Elsewhere in our columns may be found an account of the action taken by the American Institute of Electrical Engineers with respect to this apparent neglect. Inasmuch as that body was the first formally to propose an international congress for the World's Columbian Exposition, and has more than once taken action to aid in bringing about this end, it seems most singular, to say the least, that its services should have been overlooked and its existence passed by in the first official move made. We trust that this unfortunate state of affairs is due to carelessness rather than intention, and believe that the committee appointed by the Institute to look into the matter will find that such has been the case. It would be a most serious mistake if the local authorities at Chicago should attempt to hold an international gathering without the co-operation of the one organization that may best be taken to represent American electrical science. In fact few foreigners would care to come to this country for the purpose of participating in the lucubrations of a gathering of local electrical magnates and a few perfunctorily appointed government officials.

Mr. Edison's Plans for Electric Traction. ELSEWHERE in our columns we give three instructive opinions on the remarkable interview with Mr. Edison published in the New York *Herald* Oct. 25 and reprinted in our issue of last week. It is unfortunate that the distinguished inventor should have chosen to speak through the medium of a daily newspaper instead of through the technical press, since thereby he necessarily incurred the danger of being from an electrical point of view misunderstood and misinterpreted. So far as his promises of high speed railroading are concerned, we earnestly hope that he may have an opportunity to carry them out and can predict with confidence the probability of a successful result, for the subject is one that has been worked over in the last few years by not a few eminent electrical engineers and at the present time it is perfectly well understood that the difficulties in the way are not electrical, do not require any epoch making inventions for their solution, and in fact present a field in which original work is well nigh impossible except in inconsiderable and unimportant details. With respect to electric traction for street cars by the use of rail conductors and very low voltages, it is a plan that was advanced by Mr. Edison several years ago, and over the details of which he has spent no small amount of labor from time to time. Our correspondents with great unanimity express the opinion that the aforesaid method will not work successfully, and it remains for Mr. Edison to controvert them if he can by actual experiments. The feasibility of a new plan for electric traction must be demonstrated by hard every-day service, under circumstances that insure a wide variety of conditions and a veritable commercial operation of the system. Tests made in the laboratory or the shops or on selected roads under the direction of manufacturers' experts are of very little importance in determining the real working value of any given system of apparatus. There hardly exists in the files of the United States Patent Office a scheme for electric traction so hopelessly impractical that it cannot be made to work after a fashion in the laboratory, and yet one can count to-day on the fingers of a single hand the plans for the supply of a current to a moving vehicle that give even a reasonable prospect of ultimate commercial usefulness. The "proof of the pudding is in the eating," and if Mr. Edison was not indulging in a joke at the expense of an overcredulous reporter, we trust that he will straightway put his apparatus into its best working order and let it stand the crucial test of commercial application.

A Continental Electric Tramway. UP to the present nearly the entire literature of the electric railroad has had its origin in America, where electrical traction has been so far developed. A recent number of a Swiss paper, however, gives a very careful study of the details of a short electric line operated by water power. It is of particular interest as embodying some departures from our familiar methods here and the use of a new motor designed by Mr. C. E. L. Brown, until very recently engineer of the Oerlikon Works. The road is but a small one, hardly more than two miles long, and the power station has a capacity of about 40 h. p., furnished by a turbine water wheel. The line is arranged on the Sprague system and most of the line apparatus is of American manufacture. Instead of the customary American arrangement of separate motor cars a small electric locomotive is employed to drag several trailers. This locomotive is equipped with two 25 h. p. four-pole motors. The armature speed is low, only about 450 revolutions per minute, and the motors are very similar to the single reduction gear motors recently put upon the market in this country. The electromotive force used is one of the most striking points of difference from our American practice to be found in the little Sissach-Gelterkinden road. The generating dynamo is intended for a normal voltage of 700, a fact which has a considerable bearing on the excellent efficiency obtained from the motors. We may note as a curious result of the employment of water power, enormous variations in voltage in spite of a very small loss in the line, the range being from 560 to 760 volts. The results of the careful tests made on this road are of no small interest, as showing the progress that has been made by continental electricians in traction work. The power required to draw a train weighing a little over 20 tons at a speed of about eight miles per hour, proved to be a trifle less than 17 kilowatts. The commercial efficiency of the motors appeared to be, from the measurements made, about 70 per cent., a figure that is very satisfactory indeed, although it was reached under the somewhat advantageous conditions of an unusually high voltage and motors considerably larger than those used on American roads. It is incorrect, however, to say that 70 per cent. is far ahead of present American practice, for though the early motors showed by no means so good a result the later ones approximate it, as might be expected, quite closely. A fair average efficiency in the case of double reduction gear motors of recent manufacture is from 60 to 65 per cent.; the single reduction gear motors now in use are a trifle better, so that while the performance of the Brown motor used on the line in question is undoubtedly highly satisfactory, it is only a few per cent. better in the matter of efficiency than the recent machines designed and used in this country, although these are decidedly smaller and designed for a lower and hence less economical electromotive force. Altogether the impression left by the account of this interesting little Swiss road is that while the continental motor designers have done their work well they are behind the American standard of excellence in the matter of subsidiary apparatus.

Latest Foreign Electrical News.

(By Cable from Our Own Correspondent.)

LONDON, Nov. 2, 1891.—The Thomson-Houston electrical tramway line at Leeds mentioned in our last communication was opened by the mayor of that city on Thursday last. All six cars were running simultaneously and fully loaded. The motor equipment on this line consists of two 15-h. p. single reduction gear motors on each car. The maximum grades to be surmounted are about five per cent. Several other electric traction enterprises are on hand. The Southwestern Railway Company contemplates an electric subway from its terminus on the south side of the Thames into the city for the convenience of business men. This will still further improve the suburban facilities of the city.

Wolverhampton proposes to follow the example of Wallsall in the adoption of electric railway lines connecting it with neighboring towns.

Electric lighting, too, is on the increase, and the municipallty of Huddersfield is the latest to take steps in this direction. It is intended to spend £50,000 for the electric lighting of the town.

Prof. Oliver Lodge has just brought out a form of lightning arrester suitable for lighting circuits. It will be remembered that about a year ago he introduced ingenious modifications into the recent methods of protection against lightning, and the present apparatus is the outcome of some of the experiments of that period.

The Rothschilds have placed £7,000 at the disposal of Messrs. Hutin & Leblanc for the carrying out of commercial experiments with their rotary field motor.

High Voltage Experiments at Frankfort.

(By Cable from F. C. Perkins.)

FRANKFORT, Nov. 2, 1891.—As a result of the experiments made by the committee in charge of the Lauffen-Frankfort transmission plant to ascertain, by gradually increasing the voltage, what was the upper limit possible with the apparatus now in use, it is announced that a successful test has been made with 27,000 volts difference of potential.

What Other Electricians Think of Mr. Edison's Proposed Electric Railway System.

Mr. Edison's plans for the development of electric railroading, as communicated by him to a reporter of the New York *Herald* and republished in last week's ELECTRICAL WORLD, seem to have attracted a considerable amount of attention among electrical experts. No fewer than three well known electrical engineers prominently connected with the electric railway business—Prof. Elihu Thomson, Prof. Sidney H. Short and Mr. O. T. Crosby—have written to THE ELECTRICAL WORLD in reference to the important subject in which Mr. Edison seems now so deeply interested. The opinions of these gentlemen show the formidable nature of the problem that Mr. Edison has undertaken to solve, and we much regret that the great inventor is not in a position to give a clew to his hopes of success. In response to a request for information Mr. Edison declines for the present to give for publication any more details on account of his foreign patents, which must necessarily be secured if at all before full publication in this or any other country. In the mean time, here is what Prof. Thomson, Prof. Short and Mr. Crosby have to say on the subject:

PROF. ELIHU THOMSON.

It is a question with me whether the things imputed to Mr. Edison in the interview in the New York *Herald*, copied in the current issue of THE ELECTRICAL WORLD, may not just as well be allowed to go for what they are worth, and meet the fate of many other predictions which have been made from time to time. I remember distinctly that at one time Mr. Edison was said to have made the prophesy that in 10 years arc lights would cease to be used for lighting. This was, if I remember, more than 10 years ago, and the fact is simply that the arc light business has grown in spite of his predictions, and I am informed that in Europe there are numerous instances in which incandescent lamps are being replaced by the more perfect types of arc lamps with fine carbons, on account of the greater intensity of the light, as well as the economy of the lighting.

Of course I am a believer in the gradual evolution of electrical things, and I think that the electric locomotive will replace the steam locomotive in instances of concentrated traffic or on roads which have a heavy traffic, and which can be supplied by water powers. I hope, indeed, that the time may come when the steam locomotive will disappear on account of a solution having been found for the problem of obtaining electricity efficiently from the direct consumption of combustibles, but of course I am not prepared to say that this will actually come to pass.

In regard to the hints of Mr. Edison as to the solution of the street railway problem, I recall that a year and a half ago we heard similar newspaper statements that Mr. Edison was working in this direction by the use of 20 volts and a corresponding number of ampères, such as would be required to drive a car—about 1,000 more or less. This was, I believe, to be supplied by the tracks. Of course, every electrician knows as well as I that the conditions of practice in street railway work are not such as are likely to permit any such scheme to have a ghost of a chance to survive. Certainly such statements coming from Mr. Edison are calculated to retard the growth of the industry, particularly as the schemes which he puts forward as solutions of the problem of street railway work have not received the beginning of a demonstration of their feasibility, a demonstration which is hardly likely ever to be made.

Perhaps, after all, Mr. Edison is joking, and has, as it were, filled up the reporter with a piece of fiction. I am rather inclined to take this view, and hardly feel called upon to deal with the matter in any serious aspect.

PROF. SIDNEY H. SHORT.

Permit me to give my opinion in brief upon the method of operating electric railways which is outlined in the interview with Mr. Edison. As electricians are aware this method, the use of track rails as a conductor instead of an overhead trolley wire, is far from being new. It was in fact the first method tried, and was used by Mr. Daft in Baltimore, Md., upon his first electric road. Readers of THE ELECTRICAL WORLD no doubt remember that this road was built upon a private right of way, the rails placed entirely across the ties, and the third rail—the conductor—raised still higher above the road, and thoroughly insulated, so that no mud or water could interfere with the operation of the road.

I remember still with some amusement the story which went the rounds at the time, that at every country road crossing a man was stationed with boards which he placed over the rails whenever a wagon or any other vehicle had occasion to cross. The road I refer to was impracticable and was finally abandoned. I might point out several other small roads built at different times in different places on practically the same system upon which Mr. Edison is working. It is a significant fact that none of these roads are in operation to-day.

It is claimed that the voltage would be so low as to do away with the objections found insuperable in the experimental roads already abandoned. To my mind, no matter how low the voltage may be the result will be the same, for if the pressure is so low that it will do no harm to vehicles or animals coming in contact with the conductor, it will be impossible to keep contact with the rails through dust, mud, snow, etc. It is now a very common thing for a car operating with 500 volts pressure to become stranded by being insulated on dry dust or on snow.

The question of resistance comes in also as a very important one. The resistance across four or five feet of wet earth from one rail to the other in a track several miles long must of necessity be very low, so low that I think it would practically short-circuit the rails. I should like very much to measure the resistance between the rails under these conditions, in order to satisfy myself on this point. We know it to be impossible in any commercially operated piece of street railway, since the rails are bound together with tie rods, cross-over tracks, turnouts, etc., which entirely short-circuit them.

In case the rails of the track were used as conductors, it would be necessary to have insulated car axles, insulated cross-overs and connecting tracks, and practically to change our entire method of street construction. Our iron trucks on fire engines and the like would, in crossing, short-circuit the entire system, and cause serious difficulty at the driving station by short-circuiting the machines, while the iron bars and other metal contacts between the two rails would be instantly fused to them.

Granting that this low voltage could be used to advantage along the line, it would require the rail bonding to be perfect, and the electrical connections between the ends of rails to have practically no resistance. These, as we are well aware, are hard conditions to fill.

It troubles me to think of the size of the conductor that would be necessary to carry the enormous volume of current needed in such a system. To be sure, it is proposed that dynamos should be placed at short intervals along the track, and driven by motors under high pressure. This double conversion of energy is not along the line of either economy or efficiency. The expense of such an arrangement and the cost of repairs and maintenance would be prohibitory.

On the whole, while I am willing and anxious to believe it possible to operate street railways in the manner described, my experience has been such as to make me incredulous.

I am too much occupied at present to go deeply into the ifs and ands of this question; and I hardly think there will be much necessity for me to inform myself on it for several years to come.

O. T. CROSBY.

On reading the interview with Mr. Edison published in the New York *Herald*, and republished by THE ELECTRICAL WORLD, it occurred to me that what Mr. Edison said had been misunderstood. The reporter has made it appear by implication that the whole idea of electrical rapid transit on ordinary railroads was born a short time ago in Mr. Edison's brain. It is scarcely necessary to point out to the readers of THE ELECTRICAL WORLD that the subject is quite old, and that its development has been retarded by the necessity for better motor design—in which work Mr. Edison has not helped at all—and of general confidence in electrical machinery, a confidence which has largely been gained through the efforts made by the companies exploiting electrical railway apparatus.

The reporter causes Mr. Edison to be satisfied with referring to one or two pounds of coal needed in a stationary engine to produce one horse power in the machine as compared with six pounds in the locomotive. The intervening expenses, such as interest and depreciation on the dynamo plant, attendance upon same, interest and depreciation upon very expensive copper conductors, are passed over as unimportant, as are also the losses incident to these transformations. Of just what relative value these are may be calculated if one industriously sets to work to do it. Such a comparison was made by me in a paper read before the American Institute of Electrical Engineers in May of last year. The preparation of the paper followed the actual running of a three-ton car at a speed of 110 miles per hour, driven by an electric motor. I refer to this not with any thought of setting forth original work in the matter, but simply to emphasize the fact that original work cannot be done in that line. That which I did was done for the Electro-Automatic Railway Company, of Baltimore, a company organized by Mr. David G. Weems, also of Baltimore. In doing it very familiar lines were followed, since, as may readily be surmised, little can be done save to work further along the lines usual in street railway practice. The experiments referred to were made as early as 1889, but the idea represented by them was very much older than that. Plainly stated, the problem of high speed electrical railway work does not demand a genius. It demands good railroading, good engineering and plenty of money.

Mr. Edison's plan, as I understand it, seems to be this:

The power is to be transmitted in the first instance at 500 or 1,000 volts and to be received by a motor of proper voltage. This motor is to run a dynamo, the two together forming the familiar dynamo-motor combination for reducing direct currents—the two functions may, of course, be performed by one combination machine. The currents from the secondary dynamo, under pressure of about 20 volts, are to be carried to the rail of the track, thence through the motor, thence through the other rail, thence returning to the dynamo. Each of these motor-dynamo plants is to give sufficient capacity to handle the business of, say approximately, one city block of the line; that is to say, on a street of heavy traffic, enough current must be had from this secondary plant to supply five or six cars, and its capacity must therefore be in various plants from 50 to 150 h. p. The current flowing through each rail, in case there be the heavy traffic above described, will be, at a point near the secondary generating station, anywhere from 1,000 to 3,500, or even a larger number of ampères. What this will do at ordinary rail joints remains to be seen. It is also a subject of easy calculation to determine how much copper must be added to the rail in order that the loss at 20 volts even over the short distance in question shall not be considerable.

Metal tie bars, joining one rail to the other, must be given up, or be used with non-metallic bushings. At switches, turnouts, crossings, etc., the problem of preventing metallic contact between rails on opposite sides of the track would be one which would startle almost any practical track builder who knows the difficulties of using anything but metal in track construction.

The wheels, of course, must be insulated from the axles in such fashion that the system shall not be short-circuited by the car construction. This may be done by using paper wheels. There will also be necessary a very marvellous piece of commutator work, in order to take care of the enormous currents used.

It may be seen that I have somewhat amplified the details of the system as compared with the hazy outline which the reporter permits to shine through the "wizard's" smile. This amplification is based upon a knowledge received by me in the laboratory of Mr. Edison about two years ago. I feel the less hesitancy in referring to it since in Van Depoele's patent claim 4, No. 417,654, dated Dec. 17, 1889, substantially the same system is set forth, without, however, showing the feature of using the rails themselves as conductors.

It is, of course, possible that some modification of the plan outlined above may underlie the rough sketch given by Mr. Edison through the reporter, but what is said in the interview seems to point to the revival by Mr. Edison of the very plan talked of two years ago.

While there has been a great deal of loose talk on all sides concerning the possibility of using rails as a conductor on both sides—in and out—none, so far as I know, except Mr. Edison, has thought it worth while to propose the plan.

Concerning the matter as a whole, that is, the transfer from high to low potential and the use of the rails as conductors; it presents such an enormous burden in the shape of first cost of plant, together with such unusually large transmission losses from primary engine to the motor on a car, and requires such apparently impracticable changes in ordinary railroading methods, that in my opinion nothing save the magic of Mr. Edison's name could obtain for it any hearing from the interested public.

The Motor of the Frankfort-Lauffen Transmission, and Three-Phase Motors in General.*

BY CARL HERING.

To return again to the large motor shown in Fig. 5, it will be noticed that the current is led to the armature by means of three brushes and corresponding sliding contact rings, at each end of the armature. The three at each end are stated to lead to a separate and independent set of windings, of which there are, therefore, two on the armature. The other ends of these three windings of each set are simply connected together (like in the Thomson-Houston arc light machine) without any further lead, for, as explained below, the nature of these currents is such that each of the three circuits acts as a return for the other two in multiple arc. This double winding is evidently not essential, but this particular motor, which was the first of its size ever built, was constructed with two windings in order to enable them to be coupled in multiple arc or series, for making certain tests. Furthermore, it is evident that the relative positions of the field and the armature may be reversed, and if in that case the revolving field circuit is permanently short circuited, there will be no brushes or sliding contacts at all, thus simplifying the construction very materially; in that case, however, the main current must be regulated by resistances or choking coils for starting such a large motor, otherwise the initial current may be dangerously great. The designer prefers to make the moving part the armature instead of the field; the reason for this is said to be that it is the iron of the armature and not that of the field which is subjected to rapid reversals of magnetism, and in which, therefore, there is loss by hysteresis, for which reason it should be the smaller of the two masses of iron; furthermore, the lesser half of the path of the lines of force is in that case in the moving iron. The magnetism in the field changes its polarity only in proportion to what we have termed the lagging revolutions, which correspond to such a low frequency that the hysteresis in the field need not be considered.

This large motor was coupled directly to a centrifugal pump which forced water to a height of 10 metres (33 feet) from which it fell over an artificial cascade. The motor was said to be 100 h. p., but the pump appeared rather small for this output at such a small height. The motor could be run at the same time with the bank of lamps. An interesting feature about this motor was the fact that it was the first of its size ever constructed, the only guiding data which the designer (Mr. Dobrowolsky) had was that obtained from the small two-horse motor mentioned above. That such successful results were obtained from a jump from 2 to 100 h. p. certainly speaks very well for the principle, the theory, and the ability of the designer. The motor was not even run loaded in the factory before it was brought to this exhibition, owing to the fact that they had no sufficiently large generator of a three-phase current, to try it. Aside from the electrical features of this motor, it was pleasing to see how noiselessly it ran. Having no "screaming" commutator, and being free from the humming and buzzing sound of transformers and ordinary alternating current motors, it ran so noiselessly that standing with one's back to the machine it was not easy to say whether it was running or not. There is probably no other machine representing that much mechanical horse power of which the same can be said.

In connection with the present description of this motor it may not be out of place here to explain more in detail its essential differences from the Tesla and other motors. It is, we believe, universally acknowledged that Ferraris and Tesla, independently of each other, were the first workers in this field of different phased alternating current motors. The system used by Tesla, as is well known, consists of *two* alternating currents differing in phase by 90 degrees; these are passed through alternate coils of a field (or an armature, as a distinction can hardly be made in this case) and produce a revolving magnetic field, similarly to that previously explained for three currents; such a revolving field is then caused to act on a short circuited armature, as described above, and produces rotation. These two currents in the Tesla system have a common return lead, thus making a two-phase system with three leads. By calculating the intensity of the magnetism generated by these two currents (that is, the ampère turns, or simply the ampères), it can be shown that it pulsates quite materially, the maximum being about 40 per cent. greater than the minimum. In the ideal system, however, there should be no pulsation, the field should merely rotate, and not vary in intensity. This strong pulsation of the field is very objectionable, as it acts, like the reversals in a tranformer, to generate undesirable currents in the short circuited armature winding, and as this circuit should for other reasons have a low resistance, these objectionable currents become very powerfnl. It is not these currents which generate the torque. Such pulsations are not objectionable in synchronous motors, but in unsynchronous motors, like Tesla's, they act as a brake, which action is more powerful the lower the resistance of the short circuited coils and the lower the speed. The torque of the motor therefore is so much smaller at starting, at which time it ought really to be greatest. This may be noticed by the fact that in a single phased motor, like Thomson's, having a short circuited armature, it is difficult to turn the armature by hand when the alternating current passes through the field. A Tesla motor must, therefore possess this quality to a certain extent. The torque will, therefore, be equal to the difference between this braking and the propelling force, and it (the torque) will diminish as the speed diminishes, instead of increasing as would be preferable. The Tesla motor is better than the simple alternating current motors in so far that it will start with a moderate load.

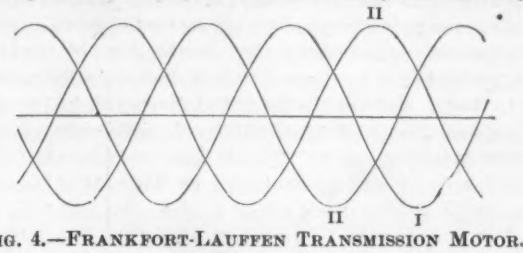


FIG. 4.—FRANKFORT-LAUFFEN TRANSMISSION MOTOR.

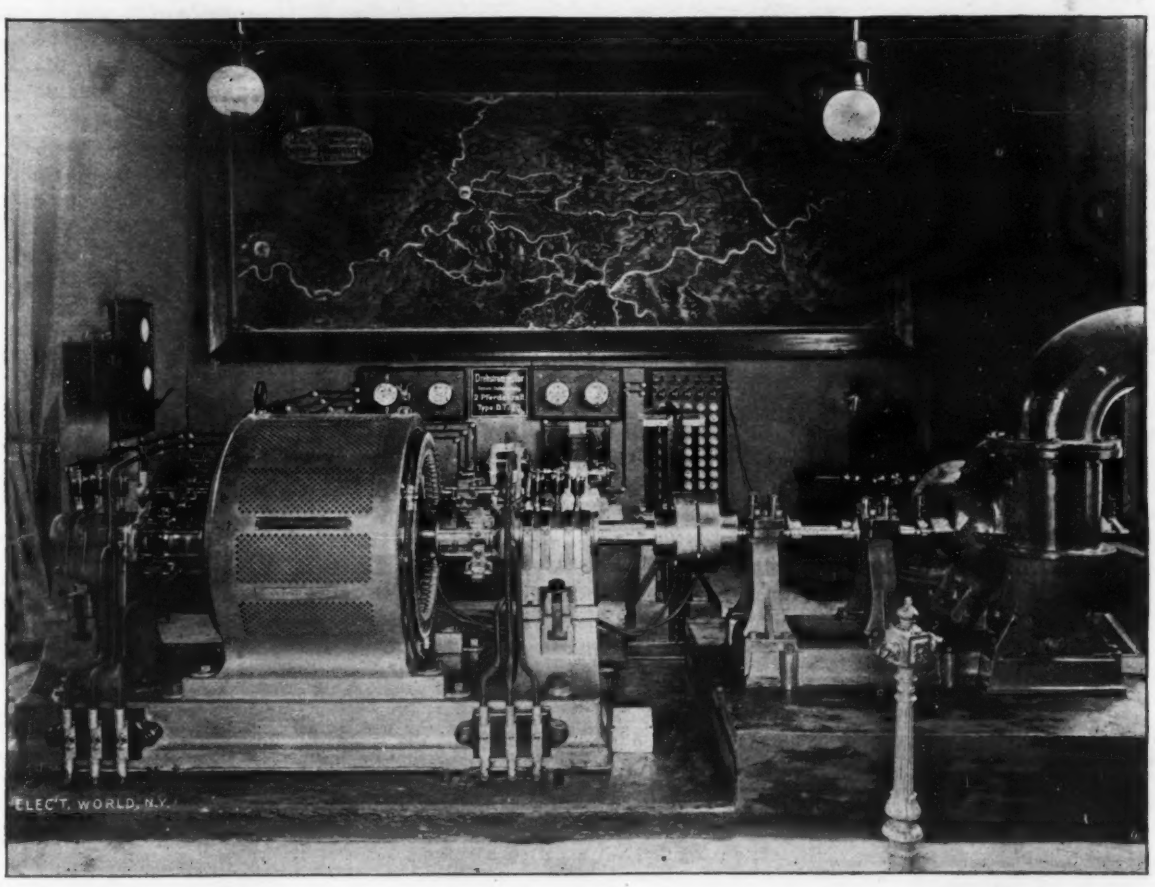


FIG. 5.—THE MOTOR OF THE FRANKFORT-LAUFFEN TRANSMISSION.

In a perfect multiple phase motor, therefore, these pulsations should be diminished as much as possible so as to avoid the objectionable induction resulting from these pulsations. In an ideal motor the revolving field would remain absolutely constant, like that of a revolving permanent magnet. By using three phases of 60 degrees in place of two phases of 90 degrees these pulsations are already greatly reduced, being only 15 per cent. in place of 40. In this lies the chief difference between the Tesla and the Dobrowolsky motors. By a very ingenious arrangement, described in THE ELECTRICAL WORLD, Sept. 19, this inventor increases the number of phases still more without increasing the number of the leads required.

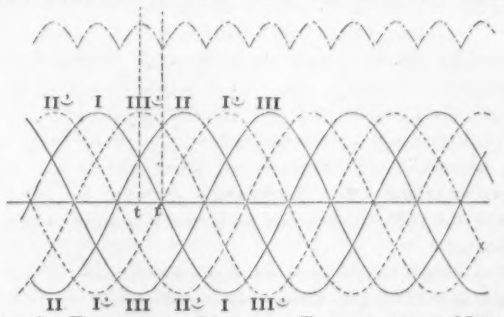


FIG. 6.—FRANKFORT-LAUFFEN TRANSMISSION MOTOR.

But to use three currents of 60 degrees similarly to Tesla's two currents would require four leads. This is overcome by the ingenious arrangement shown in Figs. 4 and 6. Instead of using three at 60 degrees difference of phase he uses three at 120 degrees difference, as shown in Fig. 4; at every moment the difference (algebraic sum) of the currents above and below the line is zero, like the lead and return of a simple alternating current, from which it follows that at every moment each lead acts as a return for the two currents in multiple arc. They may, therefore, be, and are in practice inter-connected in one of the two ways shown in Figs. 7 and 8. By this means he claims to require less copper than for two Tesla currents with three leads. Now, in the motor, a coil can be reversed in its connection, so that it will produce the same magnetic effect as a current in the opposite direction would; therefore, as far as the magnetism is concerned, each of these currents I., II., III., in Fig. 4 may also be represented by one directly opposite to it, as shown in the dotted lines in Fig. 6 and marked I.,' II.," III."'; these will then represent the same conditions as those produced by three currents of 60 degrees, although requiring only three leads equally loaded. The sum of these three currents above the line for every moment is shown in the broken line in the upper part; this line, therefore, shows the variations or pulsations of the combined currents, and, therefore, of the magnetism, which in this case is about 15 per cent. of the minimum (as 2 is to 2 sine 60 degrees, or 1.732).

In connection with this description of the Lauffen-Frankfort motor, and in the absence of tests of the large motor the following results of a very thorough test of the small 2-h. p. three-phase motor mentioned above, may be of interest. The motor is the one shown in Fig. 3 and its section in Fig. 9. The current was led to the revolving part, *M*, which he terms the magnet, while the winding in the external stationary part *A*, which he calls the armature, is short circuited. The weight was 165 kilograms (363 pounds). It was found that with two effective horse power it did not get perceptibly warm, and was therefore rated as a 2-h. p. motor. It was run with 70 volts and 35 alternations per second. The details of construction, we are informed, were designed by Mr. Brown, of the Oerlikon Works, who built this motor.

Regarding the weight, it will be seen from the following figures that compared with continuous current dynamos it is superior. To compare a motor with a dynamo, it is necessary to make a correction. As the output in either is limited to the current which the armature will stand without heating, comparative figures must be reduced to the electrical power in the armature and field. Two effective h. p. equal 1,492 watts, and as the efficiency at that output was 80 per cent. (slightly over), it represents 1,865 watts in the armature and field. This at 363 pounds gives 5.14 watts per pound for a 1.87 kilowatt motor. This may be compared with the following figures * for dynamos:

CONTINUOUS CURRENT DYNAMOS.						
Edison	3.7	watts per pound for a		1.0	kilowatt	dynamo.
"	4.5	"	"	2.5	"	"
Thomson-Houston (motor type).	5.0	"	"	1.5	"	"
French Edison Co.	5.5	"	"	2.2	"	"
Oerlikon	2.2	"	"	3.7	"	"
ALERNATING CURRENT DYNAMOS.						
Thomson-Houston	9.8	"	"	35	"	"
Zipernowski	6.5	"	"	10	"	"

It should be noticed that the alternating current dynamos were very much larger, and therefore ought to give more. These figures are from 1889 and 1890; perhaps they are slightly better now. This will show the absurdity of the statements made by a competitor at the exhibition, namely, that a motor of this kind must be four to five times as heavy as one with a separately excited field (practically the same as an alternating current dynamo).

The following curves, Fig. 10, representing the results of a set of carefully made tests of this motor, are very interesting, and will explain themselves. As will be seen, the motor was tested up to double its normal output.

From this it will be seen that the motor is by no means synchronous, but its speed falls only 6 per cent. from no load to full load, which is probably no worse, if not better than most small continuous current motors of that output. Even at 100 per cent. overload the speed shows that the motor has not the tendency to stop like synchronous motors. It will furthermore be seen from these curves that from no load, which begins at 205 watts, to 3 h. p., the effective output is nearly proportional to the watts consumed. All the curves representing energy are reduced to watts for comparison. The losses in copper resistances increase more rapidly than in direct proportion, they are the ones which cause the output curve to bend downward

* Concluded from THE ELECTRICAL WORLD of Oct. 31, 1891.

* Taken from a table in Hering's report to the United States Commissioner on the exhibits at the Paris exhibition of 1889.

from a straight line. The air and bearing friction remain about constant. The losses due to hysteresis and Foucault currents in the magnet are also nearly constant, being only a few per cent. less at the end; those in the armature, however, increase, as they depend on the lagging speed.

The values of the efficiency, taken from this, are plotted in Fig. 11. It will be seen from this that the efficiency at 1 h. p. (half load) is already 75 per cent. and at normal load over 80 per cent., being a maximum of 81.4 per cent. at 2.3 h. p. As the curve is remarkably flat it will be noticed that the efficiency remains the same for quite a long range.

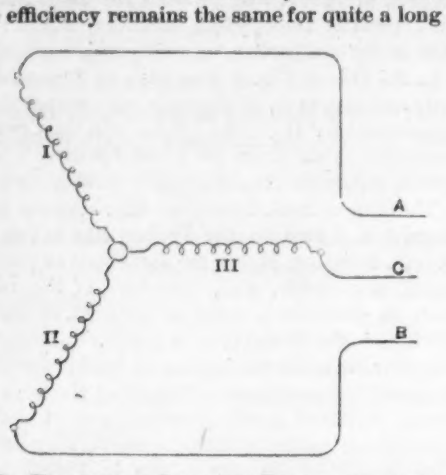


Fig. 7.—Frankfort-Lauffen Transmission Motor.

The results are certainly very good and probably exceed those even of good continuous current motors.

The inventor states that an additional advantage over many other alternating current motors is that the differences in phases between the current and the potential for the loaded motor is very small, so that the ratio between the actual and the apparent watts is nearly unity; the leads need, therefore, be no larger than for continuous currents for the same output. From the curve for the magnet current, which represents the current in one of the three circuits, and from the potential, the apparent consumption of power at normal load is $3 \times 70 \times 9.9 = 2{,}079$ watts, while that actually consumed is 1,830 watts, the ratio of which is .88. At greater loads it is far better. The lagging of phase between current and potential is 7° when running empty, 28° at 2 h. p., and 22° at 3 h. p.

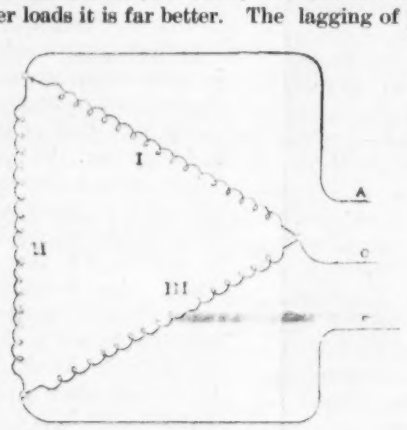


Fig. 8.—Frankfort-Lauffen Transmission Motor.

This little motor was the one which was used as a basis in calculating the large one. It might be of interest to note here that after these tests were made it was rewound for six-phase currents in place of three, in accordance with the principles described in the issue of Sept. 19, and was then found to be still better.

Besides the exhibits already described there was a small fan motor in which the armature was a simple solid cylinder of iron having only a few bare copper wires riveted through it to increase its conductivity; a simpler construction would hardly seem possible. This little motor was the first one to receive current from Lauffen at the time of the first arrival of current.

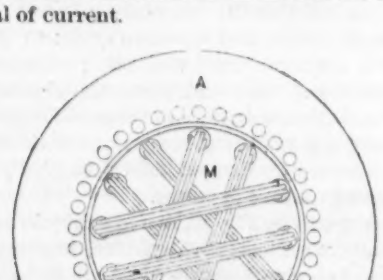
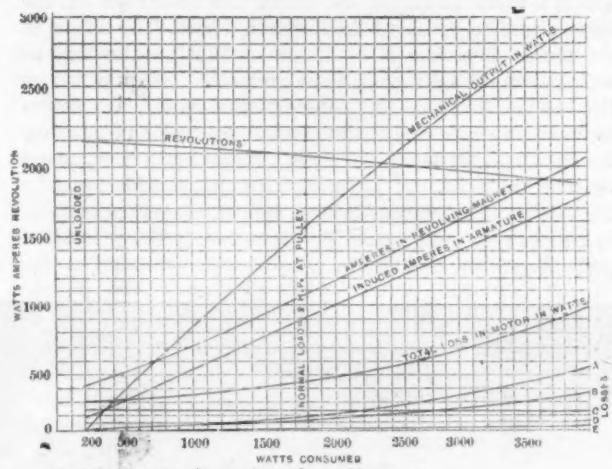


Fig. 9.—Frankfort-Lauffen Transmission Motor.

Another exhibit was that of a converter for converting a continuous current into a three-phase alternating current, or the reverse. It was used here to furnish the current for the three-phase motor Fig. 8, and took current from one of the many continuous current circuits about the building. It consisted simply of an ordinary continuous current dynamo with a drum armature, which was run as a motor and had three branch wires connected to three symmetrical parts of the armature winding, and leading to the three contact rings from which the three-phased alternating currents were led off. It acted virtually as a sort of commutating switch, rather than as a converter of the usual motor dynamo types, which always have two distinct windings.

In connection with this description of three-phase motors, it may be of interest here to add a short description which has just been received of a motor of this kind, built by the well-known engineer, Mr. C. E. L. Brown, formerly with the Oerlikon company, of Zurich. We give the description here as it was received, but desire to add that one of the first motors, if not the very first, constructed by Mr. Dobrowolsky, and seen by the writer in operation in December, 1889, in Berlin, was constructed with a short-circuited revolving armature (or field if this term be preferred), and therefore had no sliding contacts. Tesla's motors were also constructed without sliding contacts, so that Mr. Brown's claim to priority in this feature is not warranted by the facts. Brown's ability as an excellent constructor will not be questioned by any one who knows the good work he has



a = loss in copper of armature, in watts.
b = " " copper of magnet, " "
c = " " air and bearing friction, in watts.
d = " " magnetic reversals in magnet, in watts.
e = " " " " armature, in watts.
For the dotted curve read one-hundredth of vertical scale.

Fig. 10.—Frankfort-Lauffen Transmission Motor.

done, but due credit should also be given to those who originally suggested the ideas, which Brown has no doubt applied and worked out very creditably.

In the winding of the armature (which in this case is on the outside and is stationary), shown in Fig. 13, the straight radial parts represent the portions along the cylindrical surface of the armature. There are 54 of those shown (the accompanying description states that there are 90) and four poles, one alternately at every 13 and 14 wires. There are apparently six circuits, each having nine wires or half turns; three of these, marked a_1, b and c_1, terminate at the ends a_2, b_2 and c_2, respectively; the other three, a_3, b_2 and c_2^1, are connected to a common point shown in the centre. It is to be regretted that he does not give more fully his reasons for this disposition. The drawings do not at all appear to belong to the same machine. It will be noticed that a starting resistance in *series* with the motor is used in this case, as suggested in the above description, and it is

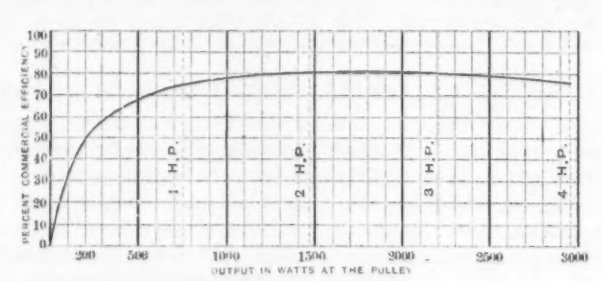


Fig. 11.—Frankfort-Lauffen Transmission Motor.

by using this means of starting that we can dispense with the sliding contacts.

C. E. L. BROWN'S 20-H. P. THREE-PHASE ALTERNATE CURRENT MOTOR.

Guided by the intention to avoid any sliding contacts with motors—as only in this way is it possible to approach the ideal of an industrial power producer—Mr. Brown took up the study of the multiphase current in the middle of last year. It was by this multiphase system that he saw a sure way to reach the above mentioned object. At the same date it was reported that the Allgemeine Elektricitäts Gesellschaft, in Berlin, had already worked out and even obtained satisfactory results, in consequence of which the Oerlikon company put itself into communication with this firm. The result was that both firms united to improve and work out the multiphase system. In August, 1890, a two-h. p. motor having no sliding contacts was finished in Oerlikon in accordance with Brown's design. This motor should be credited as being the first real commercial multiphase current motor constructed up to that date. In this motor a "hole" armature was for the first time employed in the multiphase system in connection with the Gramme winding. In the first days of the same month Brown applied the "hole" armature, in connection with the drum winding, to the 300-h. p. generator and motor designed for the electric transmission Balach-Oerlikon, which plant, as is probably not generally known, gave birth to the Frankfort-Lauffen experiment. One of these machines is the one working at present in Lauffen (see The Electrical World, Aug. 22, p. 126). The "hole" armature, in this application, offers, besides the many well known advantages, the possibility to reduce the magnetizing current to a minimum. For this reason the Allgemeine Elektricitäts Gesellschaft also adopted the same for their multiphase current motors, as, for example, in the 100-h. p. motor in the exhibition.

From the drawing Fig. 12 it will be seen that the armature is stationary and in the general arrangement is quite

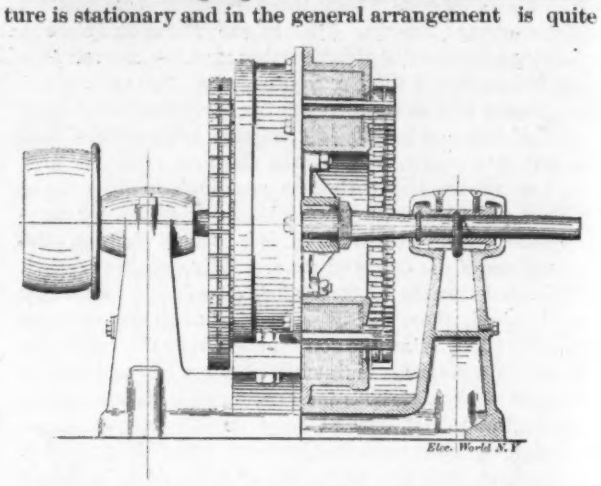


Fig. 12.—Frankfort-Lauffen Transmission Motor.

similar to the above mentioned 300-h. p. generator. In consequence of its smaller size, the armature contains more than three wires per pole. The three armature circuits are connected similarly to a Thomson-Houston arc light armature, and the winding shown in Fig. 13 is so arranged that four rotating poles are produced. With 40 cycles the motor makes about 1,200 revolutions per minute. The normal voltage for the motor is 80 volts. A reduction to 50 or an increase to over 100 will not make a practical difference in the speed. Of course, in the first case, the heating in the armature wire is a more considerable one, in the second case the heating of the iron is increased.

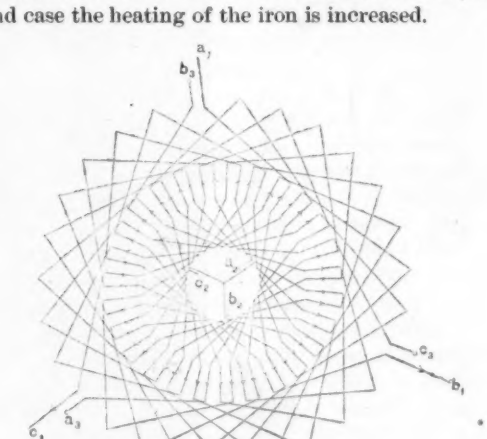


Fig. 13.—Frankfort-Lauffen Transmission Motor.

The magnetic field, in this case rotating, is produced by the armature reaction, avoiding, in this way, all sliding contacts. The magnet field (shown in Fig. 14) is composed of a laminated ring with holes, in which are placed isolated copper bars. The free ends on both sides are connected (short circuited) by copper rings. This produces the whole field, and it is not easy to imagine a more simple construction. Before giving some results of the trials, some general data of the motor may be of interest. The armature has 90 wires of about 40 square millimetres section (about a No. 1 B. & S. wire). The mode of winding and connecting up is shown diagrammatically in the drawing (Fig. 13). The copper weight is 20 kilograms, the iron weight is 100 kilograms, the breadth of the armature is 200 millimetres, the outer diameter about 500. The rotating magnet carries 54 copper bars with a section of 100 square millimetres (about a No. 0000 B. & S. wire). The weight of the copper is 15 kilograms, that

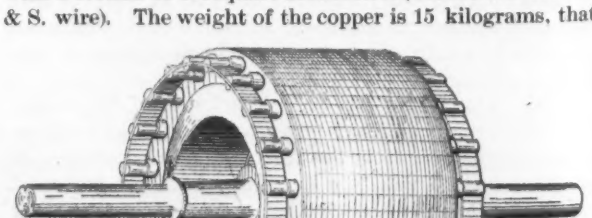


Fig. 14.—Frankfort-Lauffen Transmission Motor.

of the iron 70 kilograms. Recent trials in Oerlikon with this motor showed that it can easily supply 20 h. p. The heating, even with a continuous run, is below the normal, as no part of the motor showed a higher temperature than 20-25 degrees C. above the temperature of the test room. It may be of interest to mention that the rotating part shows practically no heating. The difference of speed between no load and full load is only 3 per cent. The torque of the motor at starting is quite a considerable one. It

could easily put into motion a 25-h. p. ventilator, or a separately excited dynamo, which was working on a dead resistance of 20 h. p. Over 200 kilograms torque could be obtained on a 20-centimetre pulley. The motor can also carry a considerable overload and runs without the least noise. The starting of the motor is similar to a continuous current motor controlled by a resistance in series with the armature circuit. Regarding the commercial efficiency, no accurate tests have been made. The losses are about as follows: In the armature copper and iron, they amount to about 4 per cent.; in the magnet copper, inclusive of friction, 4 per cent. This gives an efficiency of 92 per cent. A commercial efficiency of 90 per cent. can be taken as absolutely sure. That the losses are very small is further clearly shown by the very moderate heating in spite of the small size of the motor and the unimportant ventilation. A further advantage is that the commercial efficiency remains high even if the motor is loaded considerably below the normal. The weight of the motor is 400 kilograms, that is to say about 20 kilograms per horse power. For locomotive purposes it would not be at all difficult, nor would it influence the solidity of the design, to reduce the weight to 300 kilograms, which would be only 15 kilograms per horse power. This result must be looked at as a very good one, especially considering the low current density with which the motor is worked. As the bearings are automatically oiled, and contain large oil reservoirs, this motor can be run without any control for months.

The Elements of Practical Electricity.

BY DR. LOUIS BELL.*

Before making any attempt to measure what we know as the electric current by its effect on the magnetic needle, we may well look a little, experimentally, into this action so as to see clearly what we are going to do and how to do it. To this end let us go to work with the idea of finding out to what extent the effect of a given current on the magnetic needle changes with circumstances. We have already seen that the nearer the wire the greater the effect, and now studying the effect of changing the direction of the current on the direction of the swing of the needle, inasmuch as a current from south to north above the needle and from north to south below the needle both tend to swing it in the same direction, it is but natural to try to add the two effects and so to obtain a more marked action upon the needle. Double a piece of wire into a loop four or five inches long and perhaps half an inch wide, attach this to the battery and bring it up to your suspended needle so that one side of the loop is above and the other below it; a strong deflection will be produced, and you can see, as we have anticipated, that the effect is decidedly more considerable than if the wire had been merely above or below and at the same distance. Now go a little further yet and construct a series of loops as shown in Fig. 16. This can very readily be done by winding wire over a small block of wood, a dozen turns or so; use for this purpose rather coarse wire so that it will stay in position after the block is removed; pull apart the series of loops at the centre, as shown in the figure, so that you can get the needle inside the loops without interfering with the thread by which it is suspended. By this means you will readily find the effect of the current upon the suspended needle is very much increased, and the more loops through which the current flows the greater the effect. But you will also notice that straightening out a couple of the loops when there are 10 or 12 will increase the deflection of the needle from its original position by only a small amount. A comparatively small force from a single wire carrying a current and held over the needle will probably cause it to swing through as great an angle as the addition of two entire loops when 8 or 10 are already acting. It therefore appears that the needle is easily swung at first, but as it is deflected more and more from its original position greater and greater force is required to push it further around, and this is in fact the case.

You will probably observe in the experiment you have just tried that the needle is quite strongly affected even when it is not hung in turns of wire but is at some distance to one side of them. You can render the sidewise action much more evident by taking the coil of wire with which you magnetized needles and pieces of wire in the previous experiments and letting the current from one of your cells flow through it; present it endwise to the suspended needle, you will at once see that the latter is thrown violently aside, just as if a magnet were presented to it, and on turning your coil of wire end for end you will observe that that pole of the suspended needle which was repelled at the first trial is now attracted (Fig. 17). In fact this coil behaves precisely like a magnet with respect to another magnet. Of course if you were to thrust a bit of iron wire through the coil you would obtain more marked attraction and repulsion of the suspended magnet than before, but on removing the wire the action would be unchanged in kind although somewhat less in degree. A long coil of wire carrying current acts just like a magnet, and if suspended so as to be free to swing would promptly take up a north and south position, just as if it were a magnetized needle. Sucha long coil of wire as you have been using, the diameter of which is only a small portion of its length, is called a solenoid, and may in every respect be treated as a magnet, generally rather weak in proportion to a steel magnet of the same size, but still quite powerful. The north pole of such a solenoid may be found in exactly the same manner as a north pole of a magnet. You have already seen the relation between the direction of current in a coil and the direction in which it magnetizes an iron wire. Remove the wire and the solenoid is still magnetic, its north pole being the one in which the currents circulate in the opposite direction from the hands of a watch as you look at that particular end of the solenoid. Iron filings are readily attracted by the coil, and a thin bit of iron wire may be held suspended in its centre just as if it were clinging to a magnet. It is well to appreciate this approximate identity of solenoid and magnet before attempting to investigate any of the laws that govern such actions.

Returning now to the suspended needle and bringing it into the centre of the series of loops shown in Fig. 16, you will see that as the needle moves aside from its original position two things happen. In the first place the needle swings further from its original north and south direction, and, in the second place, if the coil by which it is surrounded is steadily held north and south as the needle swings, the

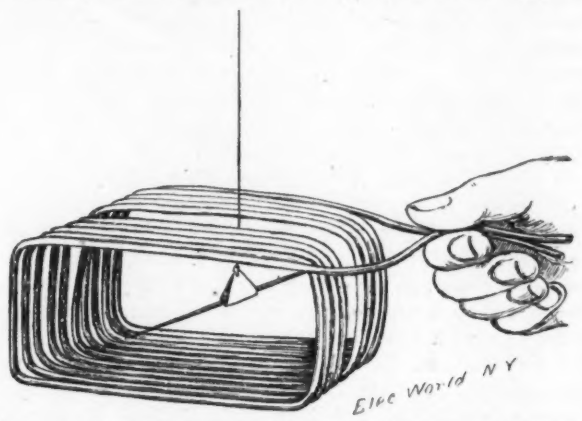


FIG. 16.—DEFLECTION OF A MAGNETIC NEEDLE BY SEVERAL TURNS OF WIRE.

poles—where, as we have already seen, magnetic action may be considered as concentrated—are brought further and further from the centre of the coil. Consequently we should expect from the previous experiments that as the needle is deflected further and further, more and more current or more and more turns of wire would continually be required to push it even a little further. The fact is that as it departs more and more from its north and south position there is a stronger force tending to pull it back, and, second, as the poles swing away from the centre of the coil that is affecting them less and less force is exerted upon them the further they move. So supposing two turns of wire connected to your battery swing the needle around through an eighth of a revolution four turns will by no means turn it through a quarter revolution. To measure a current in terms of its effect on a magnet it is necessary to take into account all these things, and this will require the application of enough mathematics to estimate, first, how the force tending to pull the suspended magnet back toward its north and south direction varies as the magnet is turned further and further from the north and south line and, second, how the effect of the coil of wire carrying the current changes as the needle is by its influence swung more and more around so that its poles get to be further from the coil. The cause tending to keep a suspended magnet in a north and south position is the magnetic action of

FIG. 17.—THE SOLENOID AS A MAGNET.

the earth, which makes itself felt at a distance just as did the action of the little solenoid shown in Fig. 17, and as the magnetism of the earth, about which we have previously said little, is on a gigantic scale and quite nearly constant in amount and direction, we shall not find it a difficult task to estimate its effect in keeping a small magnet nearly north and south against other magnetic forces that may be acting.

The Phonopore.

This remarkable telegraphic system is coming into practical use on several lines in England. According to *The Electrician* one of the Great Northern Railway Company's lines from King's Cross to Retford is fitted with it, and on the Midland Railway a duplexed passenger line between St. Pancras station and Derby is arranged with a phonopore connection for the freight service. Between the freight stations some 250 messages a day have been sent over it for the last two months. On the Great Western Railway a phonopore set is provided on a line between Paddington and Exeter, there being five single-needle intermediate stations working independently of the phonopore.

* Continued from THE ELECTRICAL WORLD of Oct. 31, 1891.

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Chronological History of Electricity, Galvanism, Magnetism and the Telegraph, from B. C. 2637 to A. D. 1888.—Part I.*

BY P. F. MOTTELAY.

A. D. 1781.——Achard (Franz Carl), able chemist and experimental philosopher, born in Prussia but of French extraction, communicates to the "Mém. de Berlin" a report of many very interesting experiments made by him, which are reviewed by Prince Dmitri Alexewitsch Fürst Gallitzin, in vol. XXII. of the *Journal de Physique.*

He had previously published essays upon the electricity of ice and the electricity developed on the surface of bodies, as well as upon terrestrial magnetism, the electrophorus, etc. He made many notable investigations to prove that fermentation is checked by electricity and that putrefaction is hastened both in electrified meats and in animals killed by the electric shock. One of his experiments illustrating galvanic irritation so greatly interested Von Humboldt that the latter repeated it with different animals, not doubting but small birds might in many cases be brought back to life when they fall into a state somewhat resembling death. He took a linnet about to expire and, having established the necessary communication, perceived, the moment the contact took place, that the linnet opened its eyes, stood erect upon its feet and fluttered its wings; it breathed, he says, during six or eight minutes and then expired tranquilly.

A namesake of Achard was the inventor of the electromagnetic brake which will be found described and illustrated in articles from the London *Engineer* and *Engineering*, reproduced through the *Scientific American Supplements*, No. 312, p. 4,974, and No. 111, p. 1,760.

See Poggendorff, "Biog.-Lit. Hand. . . ," vol. I., p. 7; "Biographie Générale," vol. I., p. 176; Cat. Roy. Soc. Sc. Papers, vol. I., p. 9; "Opus. Scelt.," vols. III., p. 313, V., p. 351, VI., p. 199; Reuss, *Repertorium*, vol. IV., p 351; Dr. G. Gregory, "Economy of Nature," London, 1804, vol. I., p. 317; Van Swinden, "Recueil . . ," La Haye, 1784, vol. I., p. 24; "Biographie Universelle," vol. I., p. 114; "Journal Lit. de Berlin," for 1776; Cavallo, London, 1777, p. 403; "Mém. de Berlin" for 1776–1780, 1786, 1790–1791; Sturgeon, "Lectures," London, 1842, p. 12; Geo. Adams, "Essay on Electricity, etc.," London, 1785, pp. 214–220, 277; "Goth. Mag.," vol. II., ii., 139; Rozier, VIII., p. 364, XV., p. 117, XIX., p. 417, XXII., p. 245, XXIII., p. 282, XXV., p. 429, XXVI., p. 378.

A. D. 1781.——Kirwan (Richard) LL. D., F. R. S., an Irish chemical philosopher of great eminence, who became President of the Dublin Society and of the Royal Irish Academy, receives from the English Royal Society its gold Copley medal for the many valuable scientific papers communicated by him to the latter body. These embrace his "Thoughts on Magnetism," wherein he treats at length of attraction, repulsion, polarity, etc., as shown in the review given at pages 346–353 of the eighth volume of Sturgeon's "Annals of Electricity, etc."

It is said that Kirwan first suggested the motion of molecular magnets, but, according to Dr. J. G. M'Kendrick, it was not till a definite form was given thereto by Weber that it acquired any importance.

See *Transactions Royal Irish Academy*, vol. VI.; Ninth "Encyl. Britannica," vol. XV., p. 276; *Phil Mag.*, vol. XXXIV., p. 247; Thomson, "Hist. of the Roy. Soc.," p. 483.

A. D. 1781.——Manduyt (Antoine René), professor at the Collège de France, publishes several observations from which he concludes that the application of electricity is favorable in cases of paralysis. He was in the habit of placing the patient upon an insulated stool, in communication with the conductor of an electrical machine. De La Rive, who mentions the fact ("Electricity," chapter III., pp. 586, 587), observes that the effect, if any, could only proceed from the escape of electricity into the air.

See Bertholon, *Elec. du Corps. Humain*, 1786, vol. I., pp. 275, 302, 439, 447, etc., and vol. II., pp. 7 and 296; "Mémoire sur les différentes manières d'administrer l'électricité, etc.," Paris, 1784; "Recueil sur l'électricité medicale, etc.," containing articles by G. F. Bianchini, De La Sone, Deshais (*vere* Sauvages), Dufay, Jalabert, Pivati Quelmalz, Veratti, Tetzell, etc.; K. G. Kuhn's works published at Leipsic, 1783–1797; E. Ducretet in "Cosmos," Paris, Oct. 3, 1891; pp. 269–272.

A. D. 1781–1783.——Don Gauthey—Gauthier or Gualtier—a monk of the Order of Citeaux, improves upon the invention of Dupuis (A. D. 1778) and constructed a telegraph, which he submitted to Dr. Franklin as well as to Condorcet and De Milly, of the Académie des Sciences, by whom it is recommended to the French government. In his prospectus, published in 1783, he relates that he has discovered a new mode of rapid transmission by which he can convey intelligence and sound by means of water pipes a distance of fifty leagues in fifty minutes. Ternant, who states this at pp. 33 and 34 of *Le Télégraphe*, Paris, 1881, adds that, as no action was taken at the time upon the prospectus, it doubtless still lies in the archives of the Academy.

See Laurenc in *Le Télégraphe*, p. 9; "Eng. Cycl.," "Arts and Sciences," vol. VIII., p. 65; "Penny Cycl.," 1842, vol. IV., p. 146.

A. D. 1782–1783.——Linguet (S. N. H.), an associate of Mallet du Pan in the preparation of the *Annales Politiques*, and who was committed to the Bastille in consequence of a

* Continued from THE ELECTRICAL WORLD of Oct. 24, 1891.

visit which he had imprudently made to Paris during 1779, writes a letter to the French Ministry proposing a novel means of transmitting messages of any length or description by means of some kind of a telegraph, "nearly as rapidly as the imagination can conceive them." He adds, "I am persuaded that in time it will become the most useful instrument of commerce for all correspondence of that kind; just as electricity will be the most powerful agent of medicine; and as the fire-pump will be the principle of all mechanic processes which require, or are to communicate, great force."

To Linguet has been attributed the authorship of the anonymous letter which appeared in the *Journal de Paris* of May 30, 1782, and in *Le Mercure de France* of June 8, 1782, wherein it is proposed to employ 24 pairs of gilt wires, placed underground in separate wooden tubes filled with resin and bearing a knob at each extremity. Between each pair of knobs was to be placed a letter of the alphabet, which letter would become discernible whenever the electric spark was passed through the wire by means of the outer and inner coating of the Leyden phial.

See Ternant, *Le Télégraphe*, Paris, 1881, p. 11; Linguet, "Mém. manuscrit . . . signaux par la lumière," Paris, 1782.

Reasons for the Use of the Three-Phase Current in the Lauffen-Frankfort Transmission.

BY C. E. L. BROWN.

The reports of THE ELECTRICAL WORLD upon the transmission of power from Lauffen to Frankfort give the impression that the application of the three-phase current alone renders such an installation possible, and that to its application is due the favorable issue of the experiment.

I wish, however, to call attention to the fact that the principal object of the experiment was to prove the possibility of producing and transmitting high tension currents over long distances by naked wires suspended from poles, and with such a degree of security against danger and such a small amount of loss by leakage as to demonstrate that this mode has commercially a right to exist.

The idea originated with me and was put to the test of experiment at Oerlikon with very encouraging results, which together with the lecture I delivered on the subject at Frankfort on the 9th of February last provoked the determination to carry out the Lauffen-Frankfort installation as it now exists.

In that lecture I propounded the view—in opposition to the general opinion at that time—that currents of 20,000 volts or more could be carried by naked wires suspended from poles on suitable insulators without excessive loss by leakage; further, I met all the questions that could arise concerning such an installation as that between Lauffen and Frankfort, and the proof of the correctness of the assertion I then advanced is that the installation in question has been carried out in accordance with my suggestions as given in my lecture referred to.

The adoption of the three-phase current only increased the difficulties to be met, since the generator, the transformer, switches and controlling appliances, as also the conductors—a most important disadvantage—became more complicated than they otherwise would have been had the usual alternating current been chosen. The only reason justifying the choice of the three-phase current was to demonstrate its advantages when applied to several small motors at the same time.

Examining closer into the three-phase current question, the only novelty which the Frankfort exhibition brings to light concerning it are important constructive improvements in its application, and these, almost without exception, I claim as my own, for the first large multiphase generator and transformer, as well as the first practical motor without moving or rubbing contact, were my constructions.

The three-phase current as applied at Frankfort is due to the labors of Mr. Tesla, and will be found clearly specified in his patents.

BADEN, Switzerland, Oct. 12, 1891.

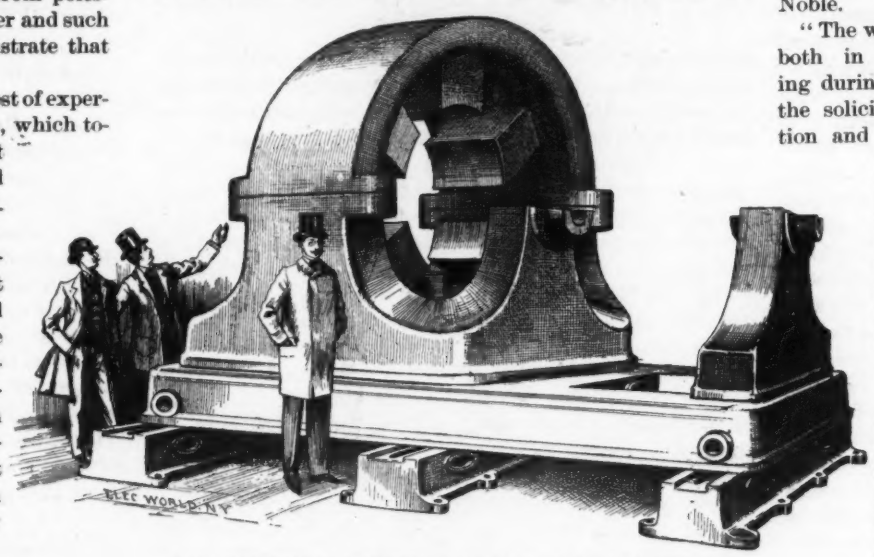
COMMENTS ON MR. BROWN'S LETTER BY CARL HERING.

In regard to the statement made in the beginning of this letter referring to my description of this transmission, I wish to say that I distinctly stated in those descriptions that the chief object of the three-phase currents, *per se*, was to enable alternate current *motors* to be run more readily than by the single phase system. I also stated, and emphasized it by repeating it in several places, that the chief object of the Lauffen-Frankfort experiment was to see whether it was practicable to transmit power on overhead lines by such high tension alternating currents, *per se*, irrespective of whether it was a three or a one phase current, as long as it was an alternating current. Nowhere do I recall having said or inferred that the "three phase current alone renders such an installation possible," except perhaps that I implied that a high tension alternating current transmission, in combination with the three-phase motor, rendered a long distance transmission of power to a *motor, practicable* (not *possible*). I am well aware (which Mr. Brown might have supposed) that it could have been done with an ordinary synchronous alternating current motor, but I said then, and think so still, that the three-phase motor is a more practicable solution. Neither did I say or infer that "to its (three-phase system) application is due the favorable issue of the experiment" except as just explained. It *is* due to the combination of the two that the practical system of a long distance transmission and distribution to a *motor* (as distinguished from lights) by alternate currents was a success. The three-phase system is evidently not essential in a simple high tension transmission of energy, and nowhere did I say this, to my knowledge. What I did say about the high tension transmission portion of this experiment, *per se*, was almost exactly what he states in the second paragraph of this letter.

I would add that I do not think Mr. Brown does proper justice to the real inventor of this modification of the Ferraris-Tesla system, namely, Dobrowolsky, when he claims that "the only novelties which the Frankfort exhibition brings to light concerning it," etc., are all his own (Brown's). It is one thing to make an invention, and it is another thing to carry it out by the best details of construction. In the latter capacity, namely, as a constructor, no one who knows Mr. Brown's works will question his ability as one of the first among electrical engineers of the present time. But without the *invention* of a new principle or a new modification, the ablest constructor would hardly be able to make any very great departures from well known systems. Due credit should therefore be given to the inventors as well as the constructors.

A Colossal Westinghouse Generator.

Among the exhibits of the Westinghouse company at the machine works was a new 500-h. p. six-pole railway generator, shown in the cut on this page. At the time of the convention it was not yet completed, but the massive castings give an excellent idea of its imposing size and solid construction. It is by all odds the largest generator ever manufactured in the Westinghouse works, and a strong candidate for being the largest American



AN IMMENSE WESTINGHOUSE GENERATOR.

built dynamo. The armature conductors in these big machines are laid under the surface of the armature in oval perforations which are afterward milled into deep slots. The commutator is singularly massive, with segments of large cross section and ample bearing surface, a precaution quite important where, as is now the case in most railway generators, carbon brushes are likely to be used.

The machines of the Westinghouse company are singularly beautiful in mechanical design and finish, and the present example partakes of the character of the smaller machines in this as in other respects. It has, however, six poles instead of four, but its electrical properties are quite similar to those of its smaller companions, and if anything can be judged from their performance its operation will be highly satisfactory. The armatures of all these machines are of particularly solid and efficient construction; they run without sparking, are quite indifferent to changes of load, and stand their full output without heating of any moment.

The Westinghouse company was very fully represented at the convention, some of the gentlemen present being Messrs. Samuel Bannister, vice-president; Albert Schmidt, Norman McCarty, E. G. Gray, H. W. Grannis, H. McL. Harding, E. H. Heinrichs and T. W. Burrows, of Pittsburgh; J. A. Rutherford and A. H. Chadbourne, of Philadelphia; J. M. Atkinson and J. L. Barclay, of Chicago; R. S. Brown, of New York, and C. B. Osgood, of Atlanta, Ga.

Westinghouse Gearless Motors for City Traffic.

BY J. L. BARCLAY.

The Street Railway Convention number of THE ELECTRICAL WORLD is before me, and the same has been perused with profit. An article headed "Gearless Motors at the Convention" attracted my attention, particularly that portion wherein the months of labor and expenditure of thousands of dollars by the Westinghouse company in producing a successful gearless motor is commented upon in some twelve or thirteen lines in the following words:

"As mentioned elsewhere, the Westinghouse gearless car was on exhibition at the convention, and ran admirably; but those most interested not only neglected to put testing instruments on the car, but refused to allow tests to be made regarding the properties of the machines, the current consumed and other details that would interest practical street railway men who judge a motor by its results on regular trips and feel more or less distrust of laboratory tests. It is only fair to state that the Westinghouse machine is designed for a considerably greater normal speed than the —— motors; hence, in a city would work at even a greater disadvantage."

This last statement is explanatory of a comment on another gearless motor made in the second paragraph of the article as follows: "It is very difficult for any motor, gearless or geared, to crawl through city streets efficiently, and the gearless type is at especial disadvantage in this respect. Its best field is on comparatively level suburban roads running at rather high speeds, and for such service it is capable of giving excellent results."

On behalf of the company I represent, I must deny the correctness of the foregoing conclusions. In relation to the so-called tests, no practical street railway man was refused permission to test the Westinghouse gearless motor. In fact, tests at the factory were made by engineers, railway managers and others during the convention.

I would ask you to correct the impression that may be made in the minds of your readers that the Westinghouse gearless is not designed for city work, and would be at a disadvantage in such work, the fact being we now manufacture three types of gearless motors; first, for heavy grade city work; second, ordinary level city lines; third, for suburban service.

The Electrical Census.

In the efforts now in progress to secure such legislation as may be necessary to carry out the work already planned by Special Agent Foote, the following letter was sent by Superintendent of Census Robert P. Porter to Secretary Noble.

"The wonderful advancement of the electrical science both in invention and successful application, occurring during the last decade, induced this office, upon the solicitation of the National Electric Light Association and other interested parties, to institute a preliminary inquiry thereinto. For this purpose Mr. Allen R. Foote, an electrical expert and author of national reputation, and a most worthy gentleman, was strongly indorsed by the National Electric Light Association and a large number of representative firms and public men. He was appointed Dec. 4, 1889, and has been indefatigable in his efforts to push the work to completion.

"It is proper to observe, however, that when it was decided to investigate this subject, it was not contemplated that the scope of the inquiry would extend beyond certain defined limits common to the special branches of productive industry. Subsequently, however, upon consultation with gentlemen interested in this subject, the schedules were so broadened as to cover details that were regarded as necessary properly to present the condition of these important industries, and the questions contained in the schedules were approved by the National Association, as well as by electrical experts and others.

"Electrical science being a newly applied industry, the cost of the investigation could not possibly be estimated with accuracy nor even approximated, but as it progressed, the expense, present and prospective, was found to be so great that I felt unwilling to divert funds from other branches of census work and employ them in behalf of an industry, however important, which would inevitably entail larger outlay than could possibly have been anticipated.

"To meet this emergency, a bill was introduced at the last Congress providing an appropriation of $50,000, to be expended specifically in making inquiry into the electrical art and industries, but it failed to pass. It then became imperative to secure, if possible, the necessary returns by correspondence, and although every effort had been made in this behalf the project did not yield satisfactory results. The reason for this failure is peculiar and anomalous. While the parties engaged in the various branches of electrical industries were entirely willing to supply information called for, they frankly admitted that they did not possess the technical knowledge incident thereto, and hence none but experts could secure the same in any other way save by personal visit to each plant.

"Hence it was determined to postpone further investigation until the Fifty-second Congress would assemble, thus relieving the Census Office, temporarily, of further expense in the premises, and accordingly an order issued to that effect.

"Upon the representations, however, of Special Agent Foote concerning the non-advisability of completely suspending the work, this order has been countermanded. The inquiry will henceforth be conducted by correspondence, so far as the same may be found practicable, with the aid of one special agent in the field.

"It should be borne in mind, however, that similar action of temporary suspension was taken with reference to all other special branches of productive industry. It was also found that the outlay required to complete the collection, examination and tabulation of the manufacturing re-

turns were so large as to render it impracticable to assign to this branch a sufficient amount, from the funds remaining on hand, to complete any part of the statistics of manfactures. Hence, I have been impelled to apply the remainder of the appropriation to the completion of the population statistics and such other branches of census investigation as could, without great expense, be immediately concluded, and meantime defer publishing the statistics of manufactures, simply maintaining the current work of that division

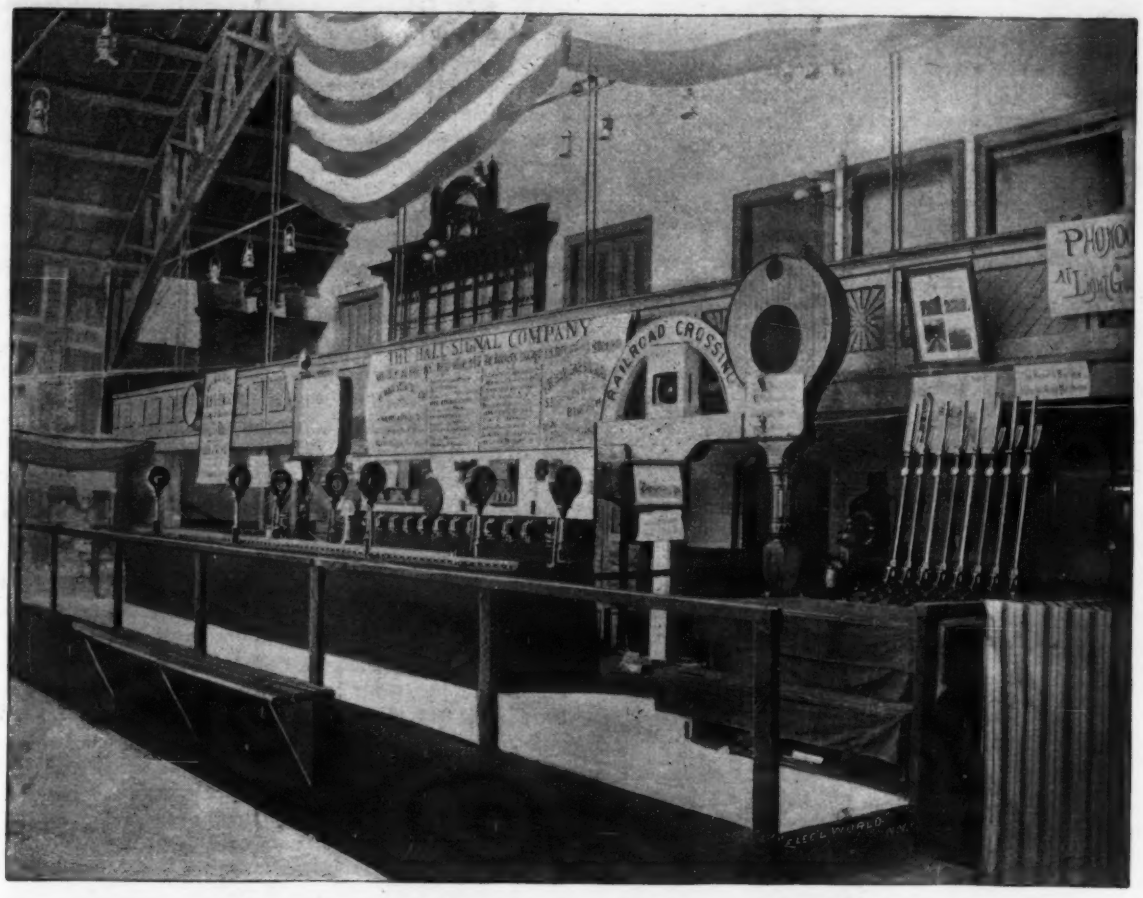


EXHIBIT OF THE HALL RAILWAY SIGNAL COMPANY, AT NEW HAVEN, CONN.

until after the meeting of Congress, and additional appropriation shall have been secured.

"In order that some idea may be formed of the great extent and value of the work now involved in the census inquiry concerning electrical industries, it may be important to state that there have been prepared, for the collection of statistics for the electrical industries for the Eleventh Census, 19 schedules and as many supplements, covering the following subjects:

1. Schedules for preliminary information.
2. Schedule for educational institutions giving a course in electrical engineering.
3. Electric light and power stations.
4. Manufactures of electrical apparatus and supplies.
5. Isolated electric light and power plants.
6. Commercial telegraph companies.
7. Commercial telephone companies.
8. Steamboat electric light and power plants.
9. Municipal electric light and power stations.
10. Uses of electricity in medicine and surgery—manufactures of apparatus.
11. Uses of electricity in medicine and surgery—medical colleges.
12. Uses of electricity in medicines and surgery—hospitals.
13. Uses of electricity in medicine and surgery—physicians.
14. Municipal fire alarm telegraphs.
15. Municipal police patrol telegraphs.
16. District messenger companies.
17. Uses of electricity in mining.
18. Telegraph lines used by steam railroad companies.
19. Electric street railroads.

"There have also been issued about 50 different forms of printed letters of inquiry and transmittal, besides numerous type written and form letters. In addition to the statistics provided for by these schedules, statistics are to be collected by letter or by personal application on the following subjects:

1. Scientific electrical instruments.
2. Ocean telegraphs.
3. Electrical distribution of time.
4. Uses of electricity by the United States government.
5. Electrical tabulating machines and registers.
6. Electroplating.
7. Electro-metallurgy.
8. Electric welding.
9. Special uses of electricity by steam railroads, such as:
   (a) Telegraphing from moving trains.
   (b) Special uses of the telephone.
   (c) Block and road-crossing signals.
   (d) Electric head-lights.
   (e) Electric train brakes.
   (f) Electric train lighting.
   (g) Uses of electric motors for operating drawbridges, turntables, traveling cranes, hoists and telpherage.
10. Electrical patents issued by the United States.

"All advices received by me, concerning the inquiries comprised in the schedules prepared under the direction of Special Agent Foote, express the conviction that they are skillfully drawn and thoroughly adapted to that purpose. It is also indicated that the parties employed in the development of electrical invention and industries will interest themselves therein, and cheerfully make response thereto—communication of supreme importance to the Census Office. The memorial and other papers are herewith returned."

The Hall Railway Signal Exhibited at New Haven.

The following is a description of the exhibit made by the Hall Railway Signal Company at the Conductors' Fair recently held at New Haven:

Two tracks illustrate the rail circuit block system, on one of which the signal stands normally at clear, but set to danger on the passage of a train or by the opening of any switch within the section, and cleared upon the train reaching a point 1,500 feet beyond the next succeeding signal. On the other track a very unique system is used, the signals standing always at danger and being cleared on the approach of a train and set again to danger on the train accepting and passing the signal. It is thus noticeable that the battery is in use only while a train is approaching, which is only a small fraction of the time, thus effecting a large saving of energy. In this system the movement of switches prevents clearing of protecting signals. Another ingenious device shown in the rail circuit line is a bell, designed for use on single tracks at crossings where no flagmen or gatemen are stationed. This bell starts to ring 1,500 feet away and continues until the train reaches and is passing the crossing. It is often used on double track roads also for protecting dangerous crossings and notifying gatemen at other crossings of an approaching train.

The working of the Standard "Hall" wire circuit block system is well illustrated by the 102 signals which are in practical operation on the New York, New Haven & Hartford Railroad. The instrument is shown in the accompanying illustration.

Another device worthy of mention is a new inclosed semaphore signal, which goes to danger by gravity, by its own weight rather than by the action of a counterweight, as in ordinary semaphore signals. The blade is made of aluminium, and in its end is placed a red glass lens, for the night signal. This signal is connected with the Stewart-Hall train order system (fully described in THE ELECTRICAL WORLD of January 24, 1891). An electric interlocking system was also shown wherein control of two or more signals is given to an operator, but after the clearing of one, control is ost over all conflicting signals until the train has completed a specified movement. At the further end of the exhibit was shown the new Bezer and Burley interlocking machine. This machine is a recent importation from England, the patents on which the Hall company controls, and has been pronounced by railroad officials to be the finest machine ever produced. Its main feature is the use of an adjustable centre on the rocker, which takes up the wear and tear to such an extent as to enable mitre locking to be accomplished, and which has always been acknowledged as the ideal form of mechanical interlocking, owing to its simplicity and ease of adjustment. The lockbox is placed horizontally and above the floor line, thus making readily accessible the tappets and dogs. The machine is a modification of the Stevens type. Mr. Bezer, one of the inventors, was for six years chief engineer for Wm. Sykes, of London, England, and Mr. Burley was for eleven years with Saxby & Farmer, of London. In addition to this interlocking machine, Mr. Bezer has a new semaphore movement, a new and simple compensator and selector, besides all the other details of a complete mechanical system, all of which the Hall company controls. This exhibit was made at a large expense to the Hall company, but was noticeably characteristic of its push and energy. Two years ago the Hall signals were in use on two roads only, but at the present time they are used on twenty-one, with other contracts waiting to be filled.

The Sissach-Gelterkinden Electric Street Railway.

A few details regarding the construction of this foreign electric railway, and some of the results of its operation, will be of interest to the readers of THE ELECTRICAL WORLD. From a recent article on the subject in *Schweizerische Bauzeitung* by Dr. A. Denzler, it appears that the whole length of the route is 3.25 kilometres, starting at the central railway station in Sissach and running by a somewhat circuitous route to the terminus at Gelterkinden. The maximum grade on the whole line is 15 per cent., and the sharpest curves are two of 60 metres radius, one of these being on a 12 per cent. grade.

The central station and turbine house are one kilometre from Sissach, the beginning of the line. The power is furnished by a Jonval turbine, which, with the mean quantity of water at a flow of 6.75 metres, is about 40 h. p. The water is supplied by the river Ergalz, and is led to the turbine house in a channel which for part of the distance is open and partly closed. As the dynamo makes 600 revolutions per minute and the turbine runs at a speed of but 98 to 100 a spur gearing is interposed between the wheel and the dynamo shaft. A so-called brake regulator is used, by means of which the turbine always runs under full load, that part of the power which is at any time not absorbed by the dynamo being taken up by the brake of the regulator. This method has been employed quite extensively in this class of work abroad, but of course it can be economically used only in those cases where the quantity of water consumed need not be taken into consideration.

The dynamo which furnishes the current for the car mo-

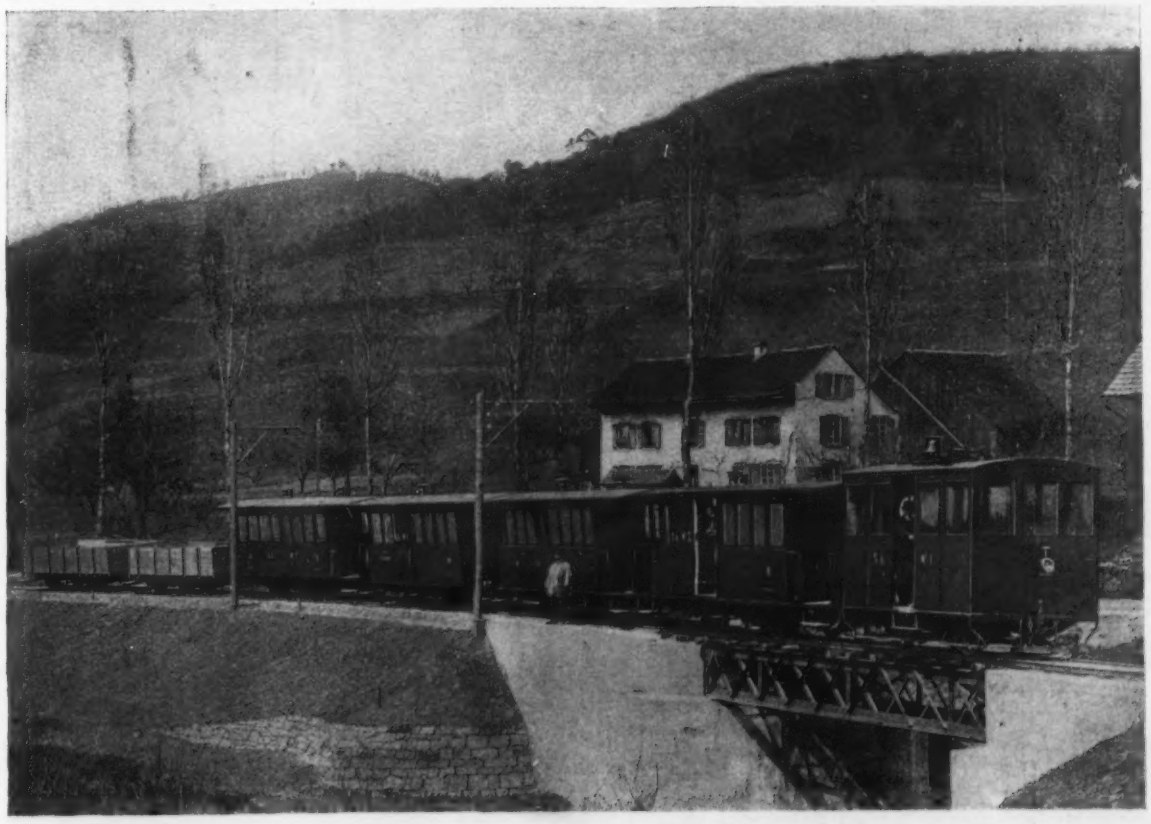


FIG. 1.—TRAIN ON THE SISSACH-GELTERKINDEN ELECTRIC RAILWAY.

tors was built for a normal output of 50 ampères at 700 volts pressure, or, in other words, about 35 kilowatts. It is a two-pole machine with series windings and a flat ring armature. The current is taken from the bronze commutator by two pairs of brushes of copper wire gauze. It is said that by using this style of brush instead of brushes of sheet copper the distributing effects of induction are not felt so much in the telephone circuits in the neighborhood of the railway lines.

The foundation of the dynamo is insulated from the ground by wooden beams, the positive pole being connected directly with the ground and the rails which end at the station, while the negative pole is connected with the station switchboard.

On the switchboard are mounted a main circuit breaker

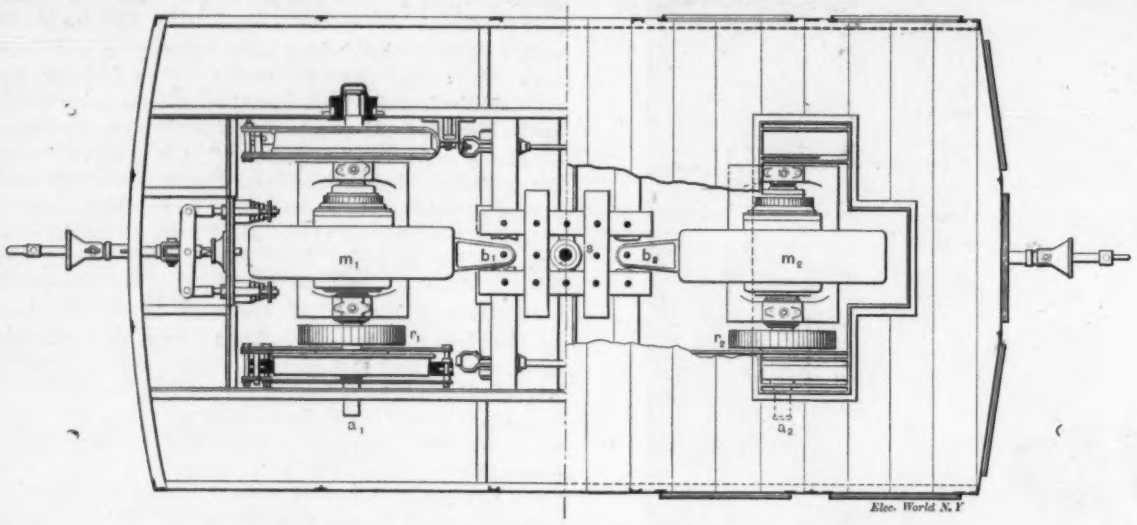


FIG. 2.—PLAN OF SISSACH-GELTERKINDEN ELECTRIC LOCOMOTIVE.

with carbon contact points, an ampère meter, a lightning arrester, and an automatic short circuiting apparatus. The first mentioned of these is designed for short circuiting the field magnet windings of the dynamo so that the current is interrupted as soon as the maximum potential has been reached. The discharge points of the lightning arrester consist of carbon rods so arranged that they can be easily replaced and can be precisely adjusted. Any arc which may be formed over these terminals by the dynamo current following to the ground when once a lightning discharge has taken place is extinguished by an arrangement which consists of a solenoid in the earth circuit, the core of which is drawn down by the continuous passage of the current through its coils. By this means the two contact points in the circuit are separated so that the arc which is established between them is extinguished. Special apparatus for regulation are not used, so that the required duties of the attending engineer in the station are considerably reduced.

A current flows in the outside circuit through the rails to the electric locomotive, and after passing through the motor returns to the station through the overhead trolley line. The rails are connected by strips of sheet copper, which are soldered and bolted to the rails; when another type of rails is used the connection is made by copper wires which are soldered to hooks of sheet copper bolted to the side of the rails. In addition to this the two rails of the track are always electrically connected by copper wires of six millimetres diameter at intervals of four rail lengths.

In addition to the overhead trolley line which forms the return, a feed wire is placed upon the bracket poles; this feed wire and the trolley line are connected in multiple arc by insulated cables at intervals of about 100 metres. By this means the overloading of the trolley wire is prevented and at the same time it is possible to use the rest of the load when the trolley wire at any section is broken. Our readers will readily recognize this as the well known Sprague system used in this country for a number of years, and it will also be noticed from the illustrations that all, or nearly all, of the line material is of the Sprague pattern, the trolley on the locomotive being the "Boston" trolley, manufactured by Anderson Brothers, of Boston, Mass.

The trolley wire consists of hard drawn copper wire six millimetres in diameter placed at the uniform height of 5½ metres above the rails. The feed wires are run on liquid insulators, while as mentioned above the trolley line insulators are of the Sprague type, and the author of the article in question points out the fact that the awkward and clumsy liquid insulators form a striking contrast with the little bell insulators used on the trolley wires.

The trolley line insulators are fastened to plain brackets made of gauze tubing. The brackets are secured to poles of round timber which are placed alternately on opposite sides of the street. The poles are 35 to 40 metres apart, and Dr. Denzler says that although it is not to be pretended that these poles are ornamental, it cannot be said that they disfigure the streets; on the contrary, one gets the impression that when light and well designed iron supports of a little greater height than those here described are used overhead wires could be employed without hesitation in the broad streets found in most of the suburbs of Swiss cities.

The construction of the electric locomotive used is plainly shown in Figs. 1 and 2, Fig. 1 being a general view of the train with the locomotive attached, and Fig. 2 being a horizontal plan of the locomotive. The most important feature of the construction is the arrangement of electric motors, which rest directly upon the car axles, a^1 a^2. Power is transmitted to the car axle through a single set of gears. The motor armatures make about 450 to 500 revolutions per minute when the train is running at its normal speed. The placing of the armature shaft and car axle in the same vertical plane is claimed to give better results than the arrangement in which the four shafts of the armatures and car wheels are placed in one horizontal plane, since under all conditions of load the same distance is maintained between the centres of the intermediate gear wheels.

The motors are four-pole machines having a normal output at full capacity of 25 h. p. These machines are built with drum armatures with windings similar to those of the Eickemeyer motor. Each motor has but a single pair of carbon brushes which press against the bronze commutator in such a position that the motor man can reach them easily even when the car is in motion. The machine has been so carefully designed that the position of the brushes remains constant under all variations of load. The current flows from the cars through the car wheels into the iron frame and then branches out into the field magnet coils of the two motors, which are connected in multiple arc; from the field magnet coils the current passes into the armatures, which are connected in series with the fields. After passing through the armatures the lines from the two machines join and pass through the regulating resistance and the ampère meter.

Between the armatures and the field magnet coils is placed a double two-pole reversing switch, by using which the circuit may be entirely opened and the train brought to a standstill, or the direction of the rotation of the armatures may be reversed and the train driven in the opposite direction. The speed of the train is regulated by resistance coils which are arranged about a central spindle, and by means of a mechanical car brake. The hand wheel by which the car brake is applied is mounted within easy reach of the motor man and is directly above the handle of the rheostat switch. It is claimed that by operating both of these hand wheels at once the motor man can stop the train within 20 metres even when running at full speed.

An alarm bell, shown in Fig. 1, is placed on top of the electric locomotive, the end of the bell cord hanging directly at the side of the motor man.

The total weight of the locomotive is 6,170 kilogrammes, the total length being 4.69 metres and the total height 2.94 metres. Usually the train consists of a locomotive and two passenger cars, one of which has a seating capacity of 24 and the other a seating capacity for 12 persons, besides considerable space for packages. The cars weigh 4,140 kilogrammes, and their total length is 7.8 metres. Dr. Denzler points out that the weight of the cars seems decidedly too great when it is considered that a common closed horse-car for 24 passengers weighs only 1,300 to 1,500 kilogrammes. Even in the favorable case, when the train consists of three fully loaded cars, the paying load of 72 passengers is 5,400 kilogrammes, while the locomotive weighs 6,170 kilogrammes, the passenger cars 16,420 kilogrammes, the train crew 150 kilogrammes; the total load is 22,740 kilogrammes. From this it will be seen that the paying load is but 23.7 per cent. of the dead load, and that but 18.3 per cent. of the total weight transported brings any revenue to the company. Dr. Denzler says: "If we compare this with the general results of an American motor car for 24 passengers equipped with two motors of 15 h. p. each, we find the mean values for the corresponding quotients 47 per cent. and 36 per cent., that is about twice as much as those given above. Even in those cases where sufficient power is available it is of no consequence to increase the efficiency of the locomotive by improved construction when the advantage thus gained is again lost by the use of too heavy cars."

For lighting the train described above it was not thought best to use electric lamps, since the frequent changes of the coupling connections between the locomotive and the cars would extinguish the lights. It is proposed in the near future to use electric heaters throughout the train.

The tests made to ascertain the amount of power consumed are of considerable interest. In Fig. 3 are shown the fluctuations of the output in watts as measured at the terminals of the dynamo at intervals of 15 seconds during a run of one kilometre. During this run the minimum and maximum output were 13.1 and 25.2 kilowatts respectively. The average of 34 measurements was 16.7 kilowatts, so that the highest and lowest values are respectively 50.8 per cent above, and 21.5 per cent. below the mean value.

The potential at the dynamo terminals varied from 560 to 760 volts. The current usually varied during the run from 17 to 30 ampères, the maximum consumption being 50 ampères, this reading being taken at the moment of starting on a 15 per cent. grade, the total output at the same time being 30.2 kilowatts. During this run the train consisted of the locomotive, 6,170 kilogrammes; three passenger cars, 12,420 kilogrammes; 30 passengers, including conductor and brakeman, 2,250 kilogrammes, or a total weight of 20,840 kilogrammes.

The largest consumption of power was 33.5 kilowatts, or 45.5 h. p. This was observed at the starting of a train of 33 tons weight on a level track. Even here the variation from the mean value during the run was but 92 per cent., while with motor cars which are provided with a double reduction gear this variation is often more than 200 or 300 per cent. To get an idea of the efficiency of the locomotive we start from the formula—

$$A = 9.81 \frac{G\,(f+s)}{\eta} \times v,$$

in which

A = number of watts per second of the work done by the dynamo,
G = weight of train in tons,
v = speed per second in metres,
s = elevation of ground in per cent., and
f = the traction co-efficient, that is, the effort which is necessary in order to move on a level track.

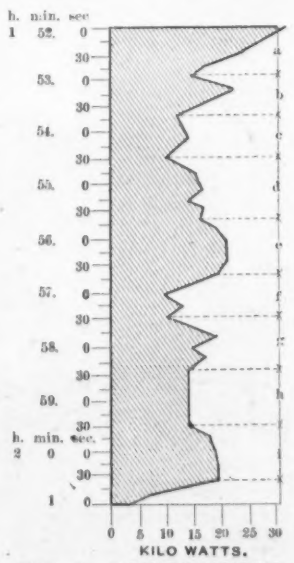


FIG. 3.—POWER CURVE.

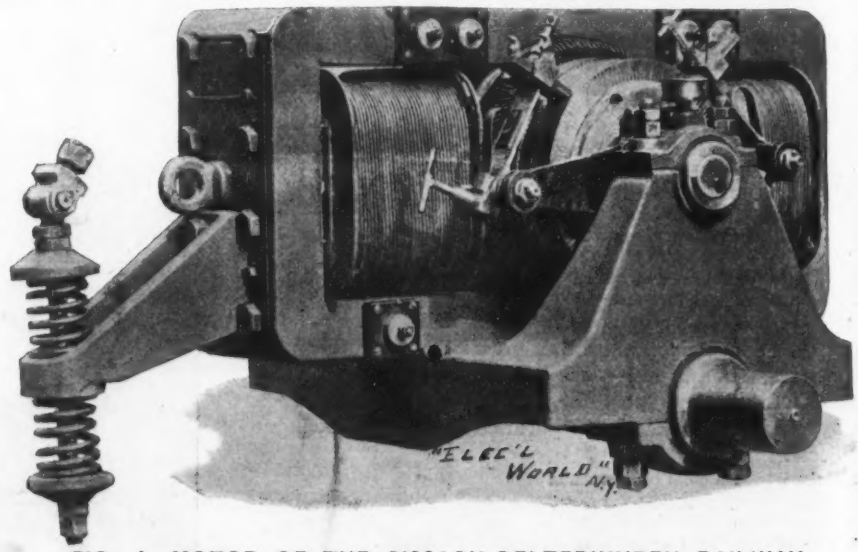


FIG. 4.—MOTOR OF THE SISSACH-GELTERKINDEN RAILWAY.

The weight $G = 1$ t.; with the speed per second $v = 1$ m., η is the quotient of the useful work done at the circumference of the wheels and the total electrical energy absorbed by the locomotive. In the above formula f and η are unknown; $A = 16{,}700$ watts; $G = 20.84$ t.; s (mean value) = 5.7 per cent.; in 8 minutes 30 seconds 2,200 m. were made. From this $t\,v = 4.3$ m. If we put these values in the formula, then we find as an approximation $\left(\frac{f+5.7}{\eta}\right) = 19$.

In order to find η we must accept for f an approximate value. If we take $f = 7.5$, which is about the mean value between that of 2.5 found at the last Paris exposition with the Décauville narrow gauge road, and the value $f = 12.2$, found by Tresca for level routes on the electric car line between Paris and Versailles, a road which is kept in good condition, then $\eta = 0.70$.

Engineer J. L. Hubel has, however, found by numerous and careful experiments on a line of horse cars in Hamburg a larger value, viz.: $f = 15$, but the conditions on the

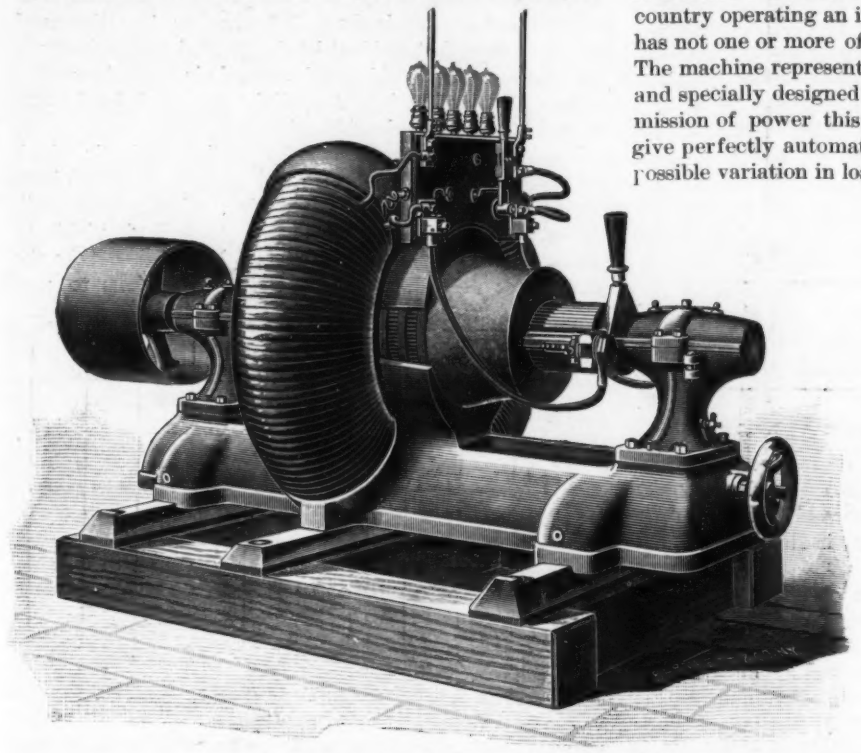
Sissach-Gelterkinden road resemble much more nearly the first two lines when "Vignol" rails are used. The measurements given above had to be made with the volt and ampère meters in use at the station, and their constants had to be accepted as correct.

Comparing these results with those obtained in this country Dr. Denzler says:

"Even if the real efficiency should be a little smaller than 70 per cent., as obtained above, still the great progress made here cannot be denied in comparison with the results obtained with the best known American systems. If we take, for instance, as a basis, the results published by Dr. Louis Bell on the electric road in Lafayette, Ind., then we get $\eta = 0.47$, even if we take Huber's larger value for $f = 15$.

Another measurement on a grade of $s = 5.3$ gave $\eta = 0.495$.

Similar results can be calculated from Crosby's experiments with reference to the roads in Cleveland, Scranton and Richmond. In no instance does the value of η exceed



A NEW TYPE OF "C. & C." DYNAMO.

50 per cent. This means that in every case about half of the expended energy is lost in the form of heat and friction when high speed motors with double transmission are used. The value obtained shows plainly that the recently applied method of increasing the efficiency of electric roads by reducing the speed of the motor is the proper one. The ideal in these regards is a motor car or an electric locomotive in which the car axles and the armature shafts are the same, so that all loss in gears is avoided.

Dr. Denzler also points out the importance in electric railway operation of deciding whether it is desirable to use independent motor cars or an electric locomotive with trail cars, and under what circumstances each system should be employed. In favor of the locomotive it is pointed out that at first larger electric motors may be employed which can be constructed for slower speed and of better design than if it is necessary to build the motors for the limited space available between the surface of the street and the floor of an ordinary car. In an electric locomotive, too, the motors are more easily accessible and can be better cared for. Dust and moisture proof appliances can be employed more conveniently, and nearly every part of the apparatus can be constructed more solidly than when smaller machines are employed. On small roads like the one described above light trains are sometimes needed and at other times heavy ones, and it is especially desirable to be able to attach freight cars to the trains at different times. For necessities of this kind there are no difficulties in the way of constructing locomotives of any desired capacity, as is the case with independent motor cars, where the space to be occupied by the motor is limited. In this latter case it is not possible to go beyond a certain size of motor, and when larger trains are needed two or more motor cars must be used, in which case additional employés are needed, although the demand for more cars may be confined to Sundays and holidays. Interest on the capital invested, then, maintenance and attendance, will cost more than when a single locomotive of large capacity is employed. The disadvantages which are connected with the use of special locomotives are pointed out by Dr. Denzler to be as follows: The length of the train is greater than when independent motor cars are used, a disadvantage which would be especially felt in narrow business streets. The first cost of an electric street railway in a city where many cars are run at the same time will be greater if electric locomotives are employed than when independent motor cars are used, while repairs and maintenance will be rather less with locomotives. For these reasons it is impossible to select either of the systems as the best for all cases. The advantages and disadvantages of each system must be carefully considered in each particular case in connection with the local circumstances and demands.

On the electric road described above nine regular trains are run daily in each direction; for freight distribution special trains are run. The time consumed in running from Sissach to Gelterkinden is 15 minutes, including stops. The stations on the line are connected with the power lines by telephone, the telephone line having a metallic circuit, the wires of which are run upon the same poles that carry the feed wire for the trolley line, and it is said that only a slight humming sound is perceptible on the telephone line when the train is in motion along the line.

A New Type "C. & C." Dynamo.

The illustration on this page is taken from a photograph of a 50-h. p. "C. & C." dynamo of a type placed on the market by the "C. & C." Electric Motor Company, of 402 Greenwich street, New York, during the past summer. The design is similar to that of the circular field and consequent pole motor that has become familiar to the public; in fact it is stated that there is not an electric light company in the country operating an incandescent circuit of any size that has not one or more of these motors connected to its wires. The machine represented in the cut is wound for 500 volts and specially designed for power circuits. For a long transmission of power this machine can be specially wound to give perfectly automatic regulation under the very greatest possible variation in load. A substantial terminal board is bolted to the upper pole piece and is provided with a heavy knife switch for opening the main circuit. This board also carries the field and armature connections, all of which are of solid metal and in plain view. The commutator is of the most substantial construction, being built up of heavy copper bars insulated with the best mica, and with proper care it will last for years. The mechanical construction is of the best throughout, skilled mechanics being employed with the most improved machine tools. The armature is wound to carry a much greater volume of current than the nominal capacity of the machine requires, thus making it practically impossible to burn them out by over-heating. The circular shape of the magnets gives them the greatest possible development of power for least weight, and every part is so constructed as to make solidity and permanence the first consideration.

The 100-h. p. dynamo made by this company is exactly the same form as the dynamo illustrated, and is especially suitable to be used as a power generator for street railway circuits on account of its high efficiency and mechanical construction.

These dynamos are wound in standard sizes from 1 h. p. to 100 h. p. for electric lighting as well as for power transmission, and especially for isolated plants and for use in mills, office buildings, banks, etc.

Although the "C. & C." Electric Motor Company has but recently entered upon this field, the long list of parties now using its dynamos for lighting purposes is an indication of the success with which it is meeting.

Action of the American Institute on the International Electrical Congress.

A meeting of the Institute Committee on the International Electrical Congress of 1893 was held in the office of the secretary, 12 West Thirty-first street, New York, on October 27.

The committee is composed of the following members: Edward Weston, Dr. S. S. Wheeler, Geo. A. Hamilton, Prof. Henry Morton, Prof. Chas. R. Cross, C. H. Haskins, R. W. Pope, Prof. W. A. Anthony, F. L. Pope, Prof. E. J. Houston, T. C. Martin, T. D. Lockwood, G. M. Phelps, C. O. Mailloux and Carl Hering.

The committee organized permanently and elected T. C. Martin chairman and R. W. Pope, secretary. It was voted that the members of the existing Committee on Units and Standards be added to the Congress Committee, also the following members: Prof. Elihu Thomson, Prof. Alexander Graham Bell, Dr. E. L. Nicholas, Mr. Nikola Tesla and Mr. Ludwig Gutmann. A sub-committee of three was appointed by the chair, composed of Messrs. Carl Hering, W. A. Anthony and A. E. Kennelly, to formulate a provisional programme for the work of the congress. The chairman is a member ex-officio of this committee.

It was recommended that the council appoint a committee to be sent to Chicago as soon as possible to represent the claims of the institute to a leading part in the congress, and to arrange for its co-operation with the authorities there upon a proper basis. The council subsequently appointed Prof. Elihu Thomson, Mr. C. H. Haskins and Mr. F. L. Pope as such committee.

At the meeting of the council the following associate members were elected:

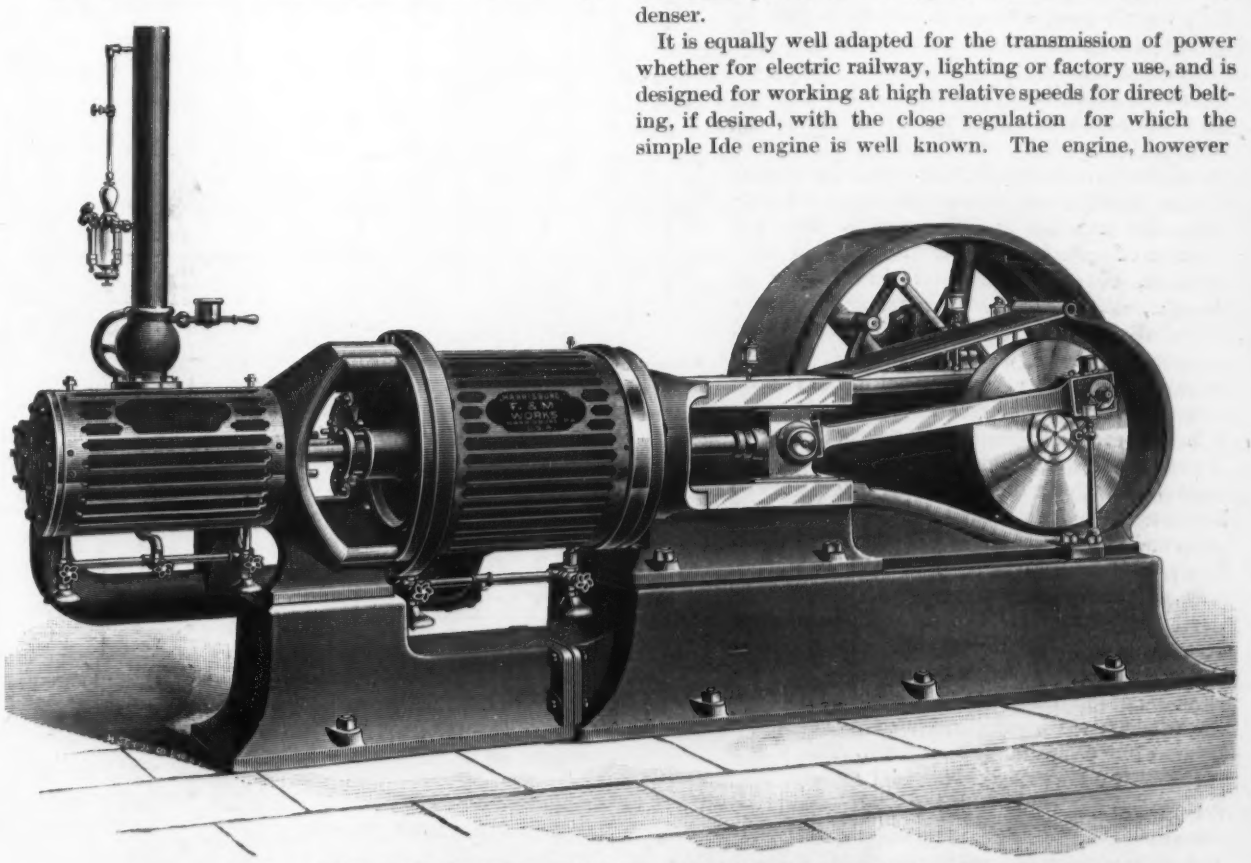
Capt. Achilles de Khotinsky, electrician, Germania Electric Company, Boston, Mass.; Robert Edward Dunston, president the Connecticut Motor Company, Plantsville, Conn.; Edward T. Middleton, instructor in electricity and physics, Rutgers College, New Brunswick, N. J.; Joseph T. Monell, with F. B. Crocker, New York City; T. Carpenter Smith, partner in firm of M. R. Muckle, Jr., & Co., Philadelphia, Pa.; Frederick G. Strong, electrician, Midland Electric Company, Denver, Colo.

At the meeting of the institute in the evening, Vice-President Lockwood presided. After the reading of a paper on "Magnetic Reluctance," by Mr. Kennelly, which was very freely discussed, the report of the Committee on Units and Standards was taken up, and after considerable discussion it was decided to take no definite action upon it at present. Prof. Ryan communicated some corrections in his paper read at the September meeting, the discussion of which was postponed.

The Harrisburg Tandem Compound Engine.

The Ide tandem compound engine as manufactured by the Harrisburg Foundry and Machine Works, of New York, Boston and Philadelphia, is shown in the accompanying cut, and is substantial and compact in design, neat and attractive in appearance, is made exceptionally large in all bearings and journals with a view of easily transmitting the maximum power of the engine when run with a condenser.

It is equally well adapted for the transmission of power whether for electric railway, lighting or factory use, and is designed for working at high relative speeds for direct belting, if desired, with the close regulation for which the simple Ide engine is well known. The engine, however



THE HARRISBURG TANDEM COMPOUND ENGINE.

maintains this close regulation to a great degree when running at comparatively slow speeds, making the engine available for all purposes. When used for electric railway work, the extra heavy shaft and flywheel are supported between bearings.

One of the special features in the Harrisburg tandem compound is the method of connecting the high and low

pressure cylinders so as to admit of moving the low pressure cylinder head for the purpose of examining the cylinder and piston without removing the high pressure cylinder or its steam and exhaust connections. The inability to do this has been one of the greatest objections to the tandem compound engines. The manner of supporting the high pressure cylinder is very substantial, avoiding the vibration of the cylinders when working under full load. The advantages obtained in making this connection between cylinders have been regarded as so important that a patent has been applied for. The general design is clearly shown in the illustration.

Magnetic Reluctance.*

BY A. E. KENNELLY.

The science of magnetism was a collection of facts concerning magnets until Coulomb first brought to light a quantitative relation between a few of its phenomena, and thus entitled it to appear among the exact sciences. He determined by measurement that the forces of attraction or repulsion between the poles of long thin bar magnets were proportional to the strengths of those poles and inversely to the square of their intervening distance.

In one respect, it has since been shown that the discovery was unfortunate, for it served to depress rather than to stimulate further inquiry into the laws of quantitative magnetic relationships. The application of Coulomb's law soon brought into use a conception of magnetism,

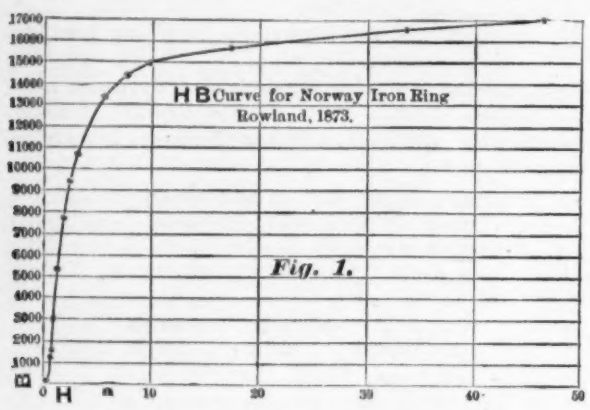


Fig. 1.—Magnetic Reluctance Curves.

suggested perhaps by the analogy the law bears to that of gravitation force. This was the hypothesis of a layer of fluid or imponderable matter resident on the surfaces of magnetic bodies and endowed with attractive and repellent forces on all portions of such fluid, in exact similarity to the two fluid theory of electricity. Each element of surface magnetism would exert according to Coulomb's law a definite force upon every other element of its own, or of other magnet surfaces, and when the distribution of the magnetic matter or fictive layer was known, the total forces active between the magnets forming the system could be determined by the summation of all the elementary actions. This was the polar conception and mathematical theory of magnetism. It was not only artificial, it was also misleading. It assumed that definite action could be exerted at a distance, ignoring the action of the intervening medium. Nevertheless, a slight modification of the polar theory rendered it capable of expressing a mathematical theory of magnetism with apparent success, and exhibits in this respect, like the theories of gravitation, the remarkable construction of purely artificial frameworks of thought, void of all attempt at reality, yet capable of affording useful applications and exact quantitative results, while beneath their foundations the real and active natural forces still lie in undiscovered concealment.

It was soon apparent that magnetism considered as a fluid could not be confined to the surface of bodies, since it was only necessary to break a bar magnet asunder in order that new poles and new magnetic fluid should be exhibited. The amendment to the original theory was then framed that a condition of molecular magnetization extended, veinlike, throughout the substance of the magnet. The termination of each vein at the surface exposed a definite quantity of polarized magnetic matter, while within the veins the polarity was neutralized by the successive layers of opposite molecular poles. This was a great stride beyond the original theory, for it ascribed magnetism not alone to a fictive superficial layer, but to the combined effects of all the molecules in the magnetized body, whose substance, no longer a mere frame for supporting the layer, became invested throughout with a definite condition.

The amendment in time became classical, and subverted the original conception, for the polar theory only recognized superficial magnetism, while the vein theory did not make any such reservation. It was only necessary to assume that the veins varied in richness at different parts of the magnet, or that they might be subjected to faults and partial discontinuities, to introduce unneutralized polarity within the mass which might be capable of exerting external influence, a condition neither the simplest nor most usual, but which the experiment of superposed magnetizations in steel has rendered familiar. This irregularity of vein structure would add a volume distribution of magnetic fluid through the interior of the magnet to the surface distribution on the outside.

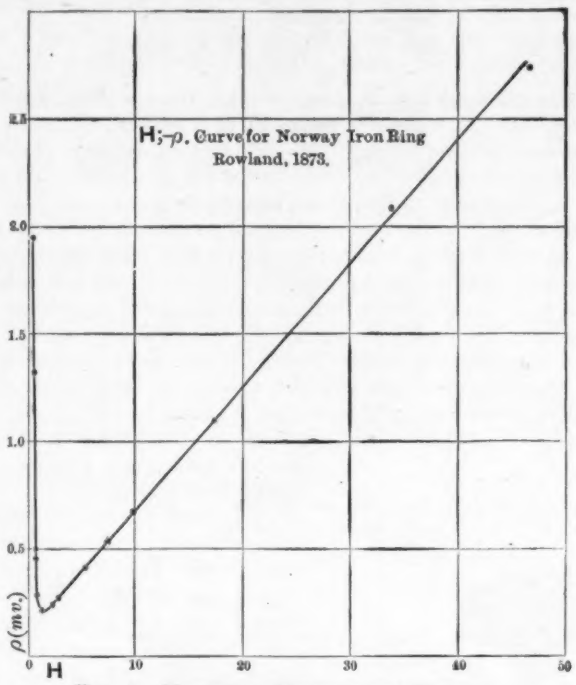


Fig. 4.—Magnetic Reluctance Curves.

On the vein theory, the intensity of magnetization at any point of the magnet would be defined as the amount of magnetic matter cut through in the veins per unit area by a plane section perpendicular to their direction, at the point in question.

A unit magnetic pole situated in free space, at the end of a very long thin bar magnet would by definition repel with unit force a similar pole one centimetre distant, that is resident on the surface of a sphere one centimetre radius, of which it occupied the centre. The surface area of this sphere would be 12.57 (4π) square centimetres, and over all this surface the pole would thus establish a magnetic field of unit strength and exert a magnetic stress equal to unity. Each square centimetre of the surface bounds an area of stress which emanates from the pole, and consequently the latter must emit 4π units of stress flux. In the language used by Faraday it would throw off 4π lines of force. This stress flux has somewhat unfortunately received from Maxwell the name of induction, and the induction through the surface surrounding the pole would be 4π units.

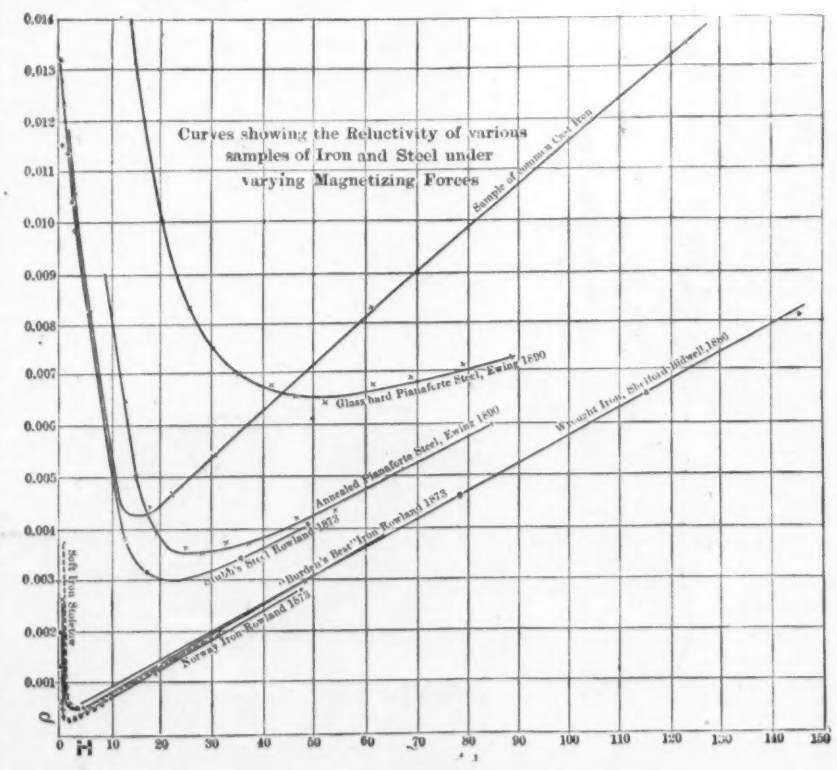

Curves showing the Reluctivity of various samples of Iron and Steel under varying Magnetizing Forces
Sample of common Cast Iron
Glasghard Pianaforte Steel, Ewing 1890
Annealed Pianaforte Steel, Ewing 1890
Wrought Iron, Sheffield-Bidwell 1890
Norway Iron-Rowland 1873
Burden's Best Iron-Rowland 1873
Soft Iron Stovepipe

FIG. 5.—MAGNETIC RELUCTANCE CURVES.

The interest connected with the nature of this stress demands a moment's pause at this point. While its real character is still as great an enigma as the real character of magnetism itself, some of its laws are well understood. There exists along the direction of the stress a tension accompanied by a general pressure at right angles, just as in the case of stimulated muscular fibre which tends to shorten and to expand laterally, or as it is generally expressed, the lines of force tend to contract while repelling one another. Since the time of discovery that the plane of undulation in polarized light waves twists in passing through certain magnetized substances it has been supposed that the stress might be of a rotary character. Like an incompressible fluid it can neither accumulate or vanish locally, and as much stress flux must leave any region as enters it, if no magnetic pole exists within the confines. Its intensity is very remarkable, for it is far in excess of any stress that we can exert without the aid of cohesion in matter. This may be judged by comparing the quantities of energy that can be stored in a given volume of space—say air space. It is of course easy even without the assistance of iron to magnetize a cubic centimetre of air to a flux density of 5,019 C. G. S. lines, when it will possess an energy stored up in magnetic stress of one meg-erg (1,000,000 ergs or 0.0737 foot-pound) while if this magnetization be alternated 227 times per second the average rate of absorption and discharge would be 45.5 watts, and one cubic inch of this air would stow and release energy with the average activity of one standard British horse power. Under electrostatic stress, air not in the immediate neighborhood of a conductor appears to break down when the E. M. F. per linear centimetre exceeds 32,000 volts or 110 A. E. S. U., so that the maximum electrostatic energy that one cubic centimetre will hold without rupture is about 500 ergs or two thousand times less than that resident in air stressed magnetically to 5,000 lines, while a cubic centimetre of air near the earth's surface illumined by bright sunlight does not hold more radiant energy than about 50 microergs.

An alternating current transformer is a device in which the secondary coil absorbs the energy out of air and iron, pervaded by the stress flux from the excited primary coil. Unfortunately, while magnetically stressed air yields, so far as we know, all its stress energy back into either the primary or secondary circuit, stressed iron fails to do so

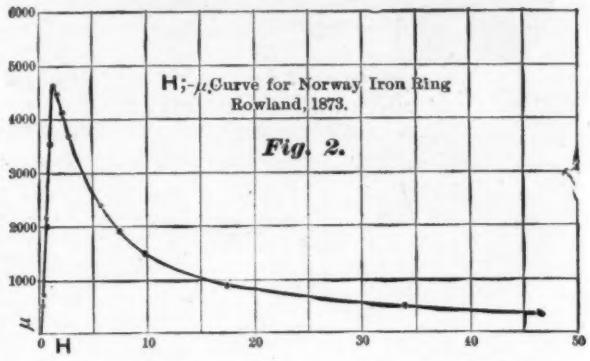


Fig. 2.—Magnetic Reluctance Curves.

entirely, and absorbs energy at every cycle, a process known as absorption by hysteresis. The iron directly converts the magnetic stress energy into heat energy, just as a spring absorbs some of the energy imparted to it during every cycle of compression and recoil.

These 4π units of stress flux are not confined to a spherical surface of one centimetre radius, but would be found by summation over any enveloping surface containing a single unit pole, just as the delivery of material liquid must be the same in a steady stream at any section of its course independent of the channel area there existing; for at ten times the distance the spherical area would be 100 times greater and the stress by Coulomb's law 100 times less, leaving the total area of stress unchanged, and it follows in fact that the stress flux over any boundary is always 4π times the strength of pole inclosed, no matter whether that pole be alone in space, or be the sum of any number of magnetic systems, in molecules or in masses.

On the vein theory, however, the strength of a pole is the quantity of magnetic matter on its surface, assuming that the veins meet it perpendicularly, or it is the aggregate surface intensity of magnetization, so that the stress flux through each unit of polar surface is 4π times the intensity of magnetization. This is true not only for the polar surface, but also for the interior of the magnet, and every unit vein of magnetic polarized matter carries associated with it a stress flux of 4π.

The magnet may itself be situated in a field of force so that its substance may be pervaded by a stress flux independent of that in its veins. It may and generally does happen that part of this separate stress flux issued from its own poles, in which case it will enter in the opposite direction to the vein or internal flux and will tend to reverse the molecular polarity of the vein structure; but whenever such additional flux is present, the resultant total flux at each point will be the geometrical resultant of that in the veins compounded with the external flux by the parallelogram of forces. In the important case of a long bar of homogeneous soft iron submitted to the influence of a uniform magnetic field acting in the direction of its length there will be a uniform induced molecular polarization or magnetization set up along the bar. Suppose for instance a bar of iron five square centimetres in uniform cross-section pointed in the direction of the dipping needle near Paris. The earth's field there being 0.46 unit, or its stress flux 0.46 unit over each normal square centimetre, that stress would be active in setting up polarity in the molecules of the iron along the bar. The degree of magnetization would be also influenced by its own resulting polar stress unless

* A paper read before the American Institute of Electrical Engineers.

this effect could be rendered insensible by sufficiently extending the length and thus carrying the poles out of the field. With a very long bar magnet the magnetization would be everywhere about 40 times this strength of field, or numerically 18.4 units, and on the vein theory there would therefore be 18.4 units of magnetic matter exposed on the surface of each square centimetre in a slice made across the bar at any point, or 92 units over the whole section. The polar surfaces would also be covered by 92 units of positive and negative matter respectively. Associated with each unit vein of polarity, however, would be 4π units of stress flux, giving a total flux of 1,156 units in the bar, which would emerge from the polar surfaces and unite in surrounding space. The whole induced system would, however, be immersed in the earth's field that evoked it, and which would be superposed upon it throughout. There would thus be 1,156 + 2.3, or 1,158.3 units of flux, in ordinary phraseology 1,158.3 lines of induction through the bar, a density of 231.6 C. G. S. units per square centimetre. The law that the whole flux is the field flux compounded with the induced flux of 4π times the magnetization, which holds uniformly at all points throughout the bar in this simple case, is true at any individual point in the most complex case, however variable the field or magnetization may be.

The fact that the stress flux has the same total value over any envelope surrounding a magnetic pole, however widely the stress may be diffused and rarefied, that it follows curves in space whose existence can be rendered evident by iron filings and curves that form closed loops through the substance of the magnet itself gradually suggested the notion of a magnetic circuit, in which the circulation was neither a fluid nor an energy exchanging condition like a current, but a stress.

This conception once firmly established proved of great advantage. Not only has the dynamo been greatly aided in development by the applications of this theory, but the inter-relationship between magnetism and electricity has been brought into clearer recognition in consequence. From this point of view the ideas and analogies of the galvanic circuit became paramount and eclipsed the original notions of magnetic matter and magnetization. All that was essential on this hypothesis was a magneto-motive force in a circuit having conductivity, and a flux or magnetic current resulted. The magneto-motive force in permanent magnets was the result of a definite molecular condition in the iron, while in the neighborhood of an electric current it was always active. According to Ampère's theory that magnets had molecules in which electric currents ever circulated, the two sources of magneto-motive force were united.

Some contention took place between the claims of the vein theory and the circuit theory for the interpretation of magnetic phenomena, and the question as to their relative merits is yet often raised. It seems, however, early to decide upon the acceptance of any theory while the ultimate origin and nature of magnetism remains unexplained, and it is better to regard both theories as working hypotheses to account for the effects of magnetic laws, equally capable of yielding correct results and therefore closely associated, while the preference between them will depend upon the nature of the problem to be attacked. The circuit theory is the simpler for general purposes of theory and particularly for dealing with the phenomena of electro-magnetism. The vein theory, on the other hand, while very artificial, is often more convenient in dealing with the magnetic behavior of the three metals, iron, cobalt and nickel, and it is the natural accompaniment of Ewing's modern theory of magnetization which at present appears to best represent the facts.

On the circuit theory the magnetic conductivity of all substances is very nearly the same as that of an air-pump vacuum, and constant, notably excepting the three magnetic metals whose conductivity is enormously greater, but variable with the conditions of the circuit.

The existence of magnetic conductivity known as "permeability" necessarily involved the inverse quality of magnetic resistance.* Some debate has taken place as to the validity of this term or its application for the reason that the resistance which usually enters into practical magnetic circuits is generally far more variable than that found in the metallic circuit of electricity. It is now generally admitted, however, that the term magnetic resistance is fairly applicable in virtue of analogy if not of exactitude. The term magnetic reluctance then suggested by Heaviside has, however, the advantage that "reluctance" as one word is less cumbrous than "magnetic resistance," and for that reason only it is advantageous to retain it. Similarly the reluctance per unit volume or the magnetic resistance of one cubic centimetre has been called "reluctivity" and is perfectly definite if not quite euphonious under that title. It is this quantity which will occupy our further attention.

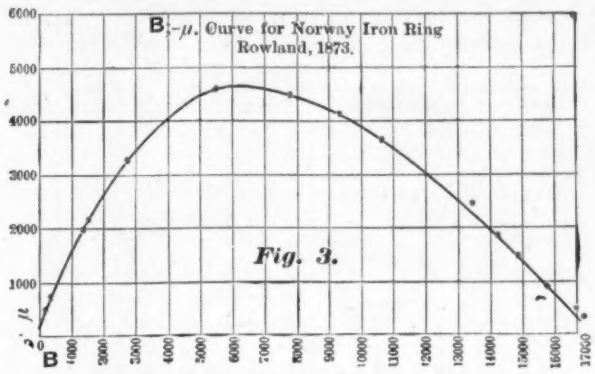


FIG. 3.—MAGNETIC RELUCTANCE CURVES.

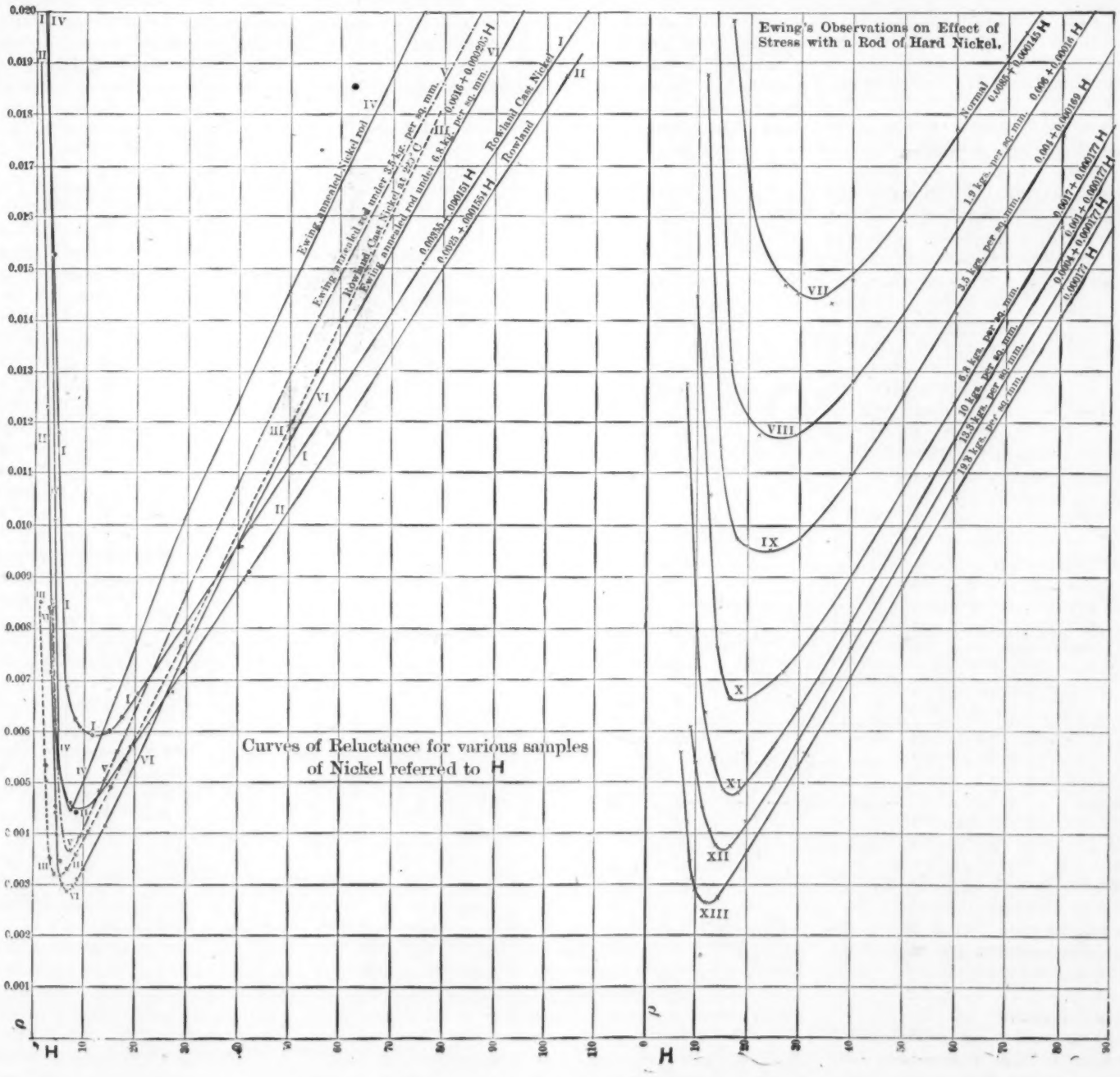
This magnetic circuit differs from the galvanic in one important particular. In the latter we most frequently meet with a conductor carrying the flux or current through an insulating medium such as air in which no current—certainly no measurable current—passes. In the magnetic circuit this condition of things while approximated to and often for practical purposes assumed in dynamos or electro-magnets is only realized in one actual instance—that of a closed Faraday ring uniformly wrapped with wire carrying a current. In every other real case the flux is diffused more or less through the surrounding substances and does not follow a simple passage. Magnetic flux in fact is not to be enchanneled because there is no known magnetic insulator, and this fetters by complication the quantitative grasp of the subject.

The law of the magnetic circuit is like Ohm's law that the flux is equal to the magneto-motive force divided by the reluctance. That is regarding the circuit as a whole. For any one point of the circuit the law is that the flux density is equal to the drop in magneto-motive force per centimetre there existing, divided by the reluctivity—corresponding exactly to the case of Ohm's law at any point in an electric circuit. This "drop" is called the magnetizing force, denoted by H, and is the strength of the magnetizing field at the point. Owing, however, to the great variation that exists in the reluctivity of iron which enters into nearly every practical magnetic circuit, the law is of much less service than Ohm's electric law. The reluctivity depends not only on the magnetizing force but also on the degree of purity of the iron, and iron possessing 12 per cent. of manganese is almost non-magnetic.*

A number of attempts have been made by different observers to establish a definite relationship between the flux density and the magnetizing force or the permeability in order to so amend the magnetic Ohm's law as to give serviceable results for even pure iron. The results obtained, excepting the formulæ of Frölich and Lamont, have generally been regarded as unsatisfactory. They have usually been expressed graphically as curves in one of three types:

1. H—B, or curves of magnetizing force and flux density.
2. H—μ, or curves connecting permeability and magnetizing force.
3. B—μ, or curves connecting flux density and permeability.

It is the object of this paper to show that there is a fourth relation that has not received the attention it seems to deserve—namely, the curves connecting the reluctance with the magnetizing force.


Ewing's Observations on Effect of Stress with a Rod of Hard Nickel.
Curves of Reluctance for various samples of Nickel referred to H
H
H

FIGS. 6 AND 7.—MAGNETIC RELUCTANCE CURVES

As an example of the comparative forms of these well-known curves types 1, 2 and 3 are represented in Figs. 1, 2 and 3 for a sample of Norway iron whose results are among the first on record, being published in 1873.† The curve connecting the reluctivity with magnetizing force is shown in Fig. 4, and exhibits a greater degree of simplicity than any of the others. Curve 4 consists in fact of two lines that are very nearly straight, united by a rounded elbow; and these outlines express the fact that the reluctance of this sample of iron was very nearly a linear function of the magnetizing stress brought to bear upon it. The ordinates for this curve are given in thousandths of an absolute reluctance unit, a quantity we may call provisionally a milli-unit, abbreviated *M U*. The reluctance of one thousand *M U* in series would then be that of one cubic centimetre of air. Reluctivity curves plotted from various sources appear in Fig. 6, shown on this page, for various samples of iron and steel. The general type consists of two lines nearly straight, connected by an elbow which is sharper and more defined as the iron is softer and more nearly pure. With hard steel the change from the descending to the ascending line is very gradual. The reluctivity of iron appears from these curves to commence at a certain definite and moderately large value which we

*Bosanquet. *Phil. Mag.*, Vol. XXV., 1888, p. 419.

*Hopkinson. *Phil. Trans.*, 1885, part II., p. 462.
†Rowland. *Phil. Mag.*, 1878, p. 153, table V.

may denominate its initial reluctivity, descends very rapidly and nearly on a straight line to what may be called the critical reluctivity at the critical magnetizing force, turns abruptly, and then advances along a nearly straight line. Before the turning point in Fig. 4 the reluctivity may be expressed approximately by the equation $\rho = 2.9 - 3.5\,H$, while beyond the bend the equation becomes $\rho = 0.1 + 0.058\,H$. The flux density existing in this sample of Norway iron can be calculated by the Ohm's law formula for any value of H when the corresponding value of the reluctivity is taken from one or other of these two equations and the resulting curve of B—H will practically coincide with that in Fig. 1 except in the immediate neighborhood of the critical value of H. This relation also exhibits the foundation that exists for the Frölich formula which has long been known to be practically valuable and even very accurate in application to dynamo-magnetic circuits, although both the method by which it was arrived at and the light in which it has since been regarded appear to have been empirical rather than fundamental. *

Fig. 6 shows that the minimum reluctivity for soft iron is about 0.15 $M\,U$, while its initial reluctivity is about 3.0 $M\,U$. The critical value of H is also in the neighborhood of 2. If any critical H can be said to exist for glass hard piano-forte wire it would be in the neighborhood of 35 units, and every description of hard or impure iron met with in practice not containing much manganese appears to have its critical H between these limits. These reluctivity curves also illustrate perhaps more clearly than any others the leading features of Ewing's theory of magnetization. There is first the initial stage of diminishing reluctivity during which the imaginary molecular magnets are being deflected from their original configurations, then a short critical range of magnetizing force in which nearly all the original groupings are disrupted at the point of lowest reluctance, and finally a steady increase of reluctance as the molecules are gradually forced by increasing magnetic stress into parallelism.

This bilinear characteristic curve of reluctivity is not confined only to iron. Fig. 6 shows the same general outlines in the case of nickel taken from the observations of Rowland and Ewing. Here the initial reluctivities are higher, and the descent to the critical points much sharper than in iron, while the ascending lines are also steep but nearly straight.

Taking the equation $\rho = a + b\,H$ in the ascending curve the first term a only disappears in one known instance—that of nickel under a mechanical stress of 19.8 kilograms per square millimetre, or 28,160 pounds per square inch—as seen in Fig. 7, taken from Ewing's results. The lowest ascending curve prolonged downward almost meets the origin. Consequently the flux equation for such nickel would be

$$B = \frac{H}{b\,H} = \frac{1}{b} = \frac{1}{0.000177} = 5650,$$

and this flux is practically constant for any magnetizing force within further considerable limits, representing early saturation. The influence of compression in diminishing the reluctance of nickel is clearly shown in Fig. 7. The critical reluctance is gradually diminished by the stress applied from 14.5 $M\,U$ at H 30, to 2.6 $M\,U$ at H 12.

Fig. 8 gives the corresponding curves for cobalt. The same features are again observable. Only in one case, that of cast cobalt at 230° C., is there any considerable deviation from a straight line in either rise or descent from the critical segment of the curve, and this represents a series observed by Rowland under some experimental difficulties and alluded to as somewhat doubtful.

* Frölich, *Electrotechnische Zeitschrift*, pp. 90, 139, 1881; p. 73, 1882. Silvanus Thompson, "Dynamo Electric Machinery," p. 305; "Lecture on the Electromagnet," I., p. 74. Ayrton & Perry, *Phil. Mag.*, 1883, vol. XXV., p. 506.

We have now examined the reluctance of the three magnetic metals collected from all the best known experimental observations. In addition to these it appears that every reliable series of tabulated results for iron, pure, impure, cast or forged, exhibits the same types of bilinear reluctance referred to H between 0 and 150, although in very hard or impure specimens there is no clear indication of a critical point. This assumes, however, that the observations are not vitiated by residual magnetism. For example, the curve obtained by plotting the reluctivities of cast iron as quoted by Silvanus Thompson from Hopkinson's observations * differs considerably from this type, but the difference appears to be accounted for by taking the mean between ascending

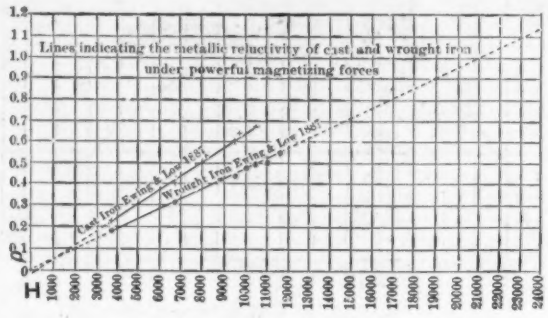

Lines indicating the metallic reluctivity of cast and wrought iron under powerful magnetizing forces
Cast Iron Ewing & Low 1887
Wrought Iron Ewing & Low 1887
ρ
H

Fig. 10.—Magnetic Reluctance Curves.

and descending values. The ballistic method of measurement with anchor rings, in which the progress of the magnetizing force takes place by extending reversals, gives reluctances that appear to be as nearly linear as those which are obtained by a single increasing amplitude of magnetization, the influence of hysteresis being apparently nearly uniform in ratio.

An examination of reluctivity curves naturally suggests the question as to whether there is really a strict linear relationship between H and p. In other words, whether the divergences of the observation curves from geometrical straight lines can be fairly ascribed to errors of observation allowing for the influences of residual magnetism.

First confining the inquiry to the ascending reluctivity line—that which is geometrically consequent upon Frölich's formula and also under special interpretation with Lamont's formula—the agreement of the plotted observations with a straight line between the neighborhood of the critical H and $H = 150$ is often so good as to intimate the existence of a definite linear relationship. It is generally to be found, however, that beyond 150 C. G. S. units of H, the line bends downward until all hope of rectilinearity is lost. That is on the simple circuit theory of reluctance. If, however, we introduce an amendment into the definition of reluctance borrowed from the vein of polar theory the rectilinearity appears to be nearly sustained for a much greater distance. Experimental observations of the reluctances in circuits of the magnetic metals under powerful magneto-motive forces are yet very scanty, but judging from the results of Ewing and Low † the reluctivity of wrought and cast iron by the amended definition appears to be a linear or at least nearly linear function of the force as far as H 25,000 and H 11,000 respectively, the limits of the quoted measurements.

The results of these measurements are given in Fig. 10. The observations run from H 3,630 to 11,200 for wrought iron, with an isolated observation at H 24,500 in a separate instance, the similar series for cast iron running from 3,900 to 10,610 units of H. The linear relationship is very fairly maintained, and the lines prolonged downward nearly strike the origin. It is to be observed that at the limiting observation for wrought iron its reluctivity is nearly 20 per cent. greater than that of air or of the air pump vacuum.

According to the simple circuit theory, the reluctance is, of course, the ratio of the magneto-motive force to the flux and the reluctivity this quantity locally reduced to the unit of volume. On the vein theory, however, which, as we have seen, distinguishes the vein flux from the magnetizing flux superposed thereon, the conductivity of a mass of iron is the conductivity of the iron itself added to that of the space it occupies, and, consequently, applying the vein theory to the magnetic circuit we have the apparent reluctance of the iron mass as the joint reluctance of two paths in multiple are, one through the iron itself and what might be called its metallic reluctance, the other through the reluctance of the space occupied by the iron, and the removal of the iron would leave this latter unaltered. The difference between the apparent and metallic reluctance is inappreciable while the latter remains small, that is generally speaking when H is below 150, a limit rarely exceeded, and, consequently, the question does not present itself under practical conditions, but for large values of H the difference is considerable and the metallic reluctance approaches the linear relationship with H while the apparent reluctance deviates considerably from it.

These assumptions from the vein theory, while they may be convenient are somewhat artificial, for they postulate that the space reluctance of a given volume of air is not altered when the volume is occupied by iron. This may not be impossible, but it is difficult to imagine any reluctance mechanism of ether that would remain undisturbed by the introduction of a massive substance. On the other hand, while the vein theory imposes this principle not touched upon by the circuital-hypothesis, it explains very satisfactorily the fact now apparently beyond dispute, that while iron can be saturated there is no limit yet attained to the flux density that can be made to pass through it. Ewing's results give no limit at the observed flux density of 45,350 C. G. S., nearly three times the flux density at which iron is commonly worked in practice, while at the same time they indicate a limiting value of magnetization long before that density is reached. Following the vein theory, the polarization of the iron is then complete and the intensity of magnetization or magnetic matter per unit cross section of veins finds its maximum, so that while the total flux can go on increasing indefinitely, it can only do so by adding to the permeating field flux, the vein flux having reached its full limit. It is not impossible to represent the observed condition of affairs by the simple circuit theory, but the mental picture is not so clear. It would be possible for instance to imagine that the molecules of all substances transmitted the stress flux with the same or almost the same facility as the ether surrounding them, but that in the magnetic metals they exalted the stress in transmission. Maxwell supposed that the iron molecules were so constructed that they could take part in the ether spin that might constitute the stress, and if so by adding it to their momentum of revolution they could augment its value. There would be then perhaps at a certain stress a speed of revolution which the iron molecules would not exceed and their reinforcement would be at a maximum, while for stresses enormously greater than this the molecular augmentation would be lost in comparison with the strength of

* Silvanus Thompson, "Dynamo Electric Machinery," p. 302.
† "*The Electrician*," London, 1890, July 25 and Aug. 1.

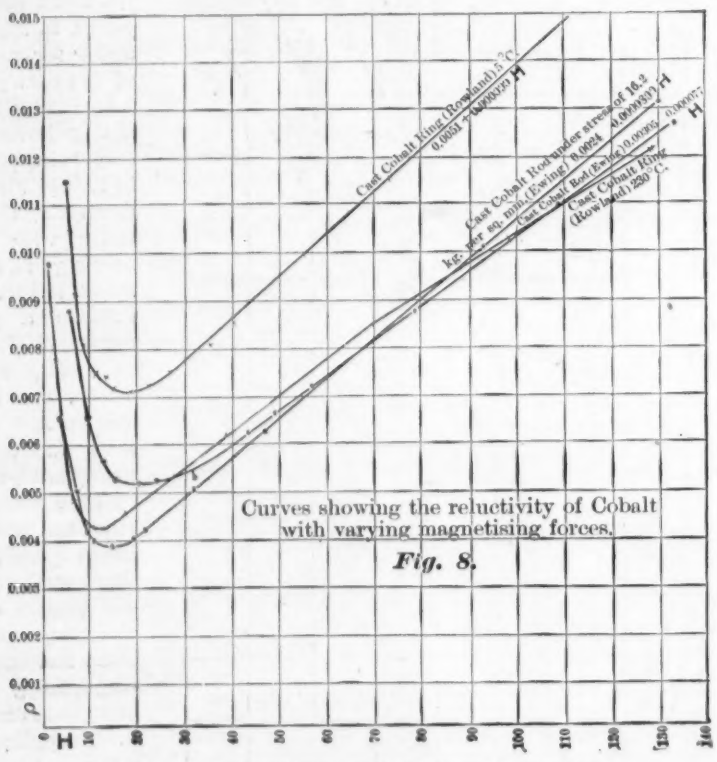

Cast Cobalt Ring (Rowland) 5° C.
Cast Cobalt Rod under stress of 16.3 kg. per sq. mm. (Ewing)
Cast Cobalt Rod (Ewing)
Cast Cobalt Ring (Rowland) 230° C.
Curves showing the reluctivity of Cobalt with varying magnetising forces.
ρ
H

Fig. 8.

FIG. 8.—MAGNETIC RELUCTANCE CURVES.

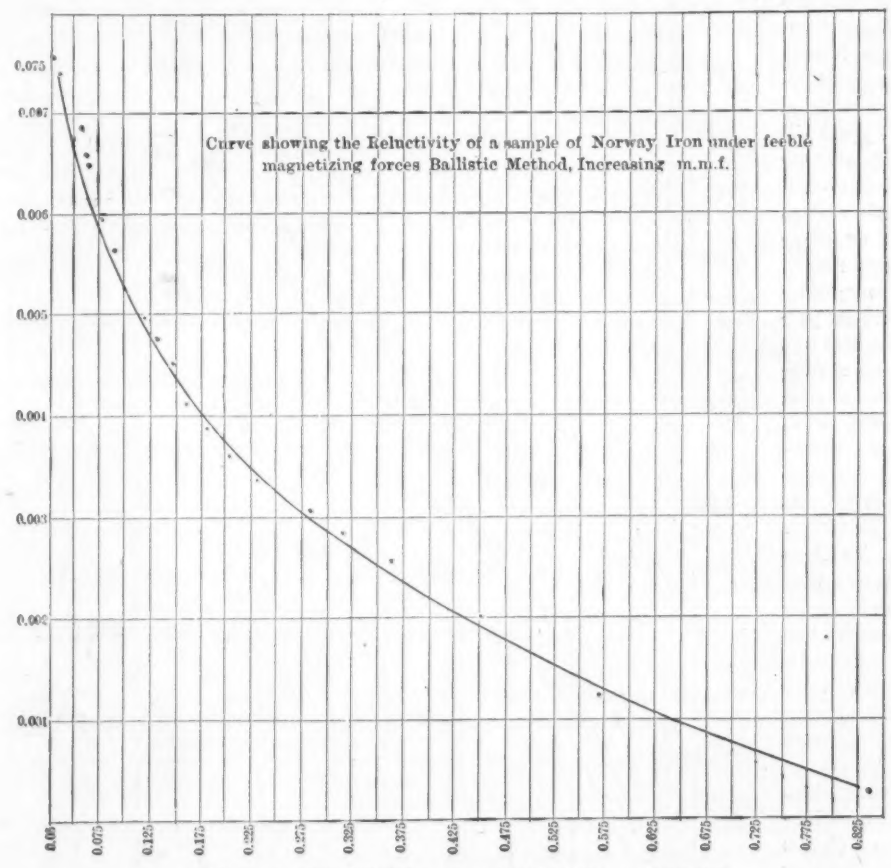

Curve showing the Reluctivity of a sample of Norway Iron under feeble magnetizing forces Ballistic Method, Increasing m.m.f.

FIG. 9.—MAGNETIC RELUCTANCE CURVES.

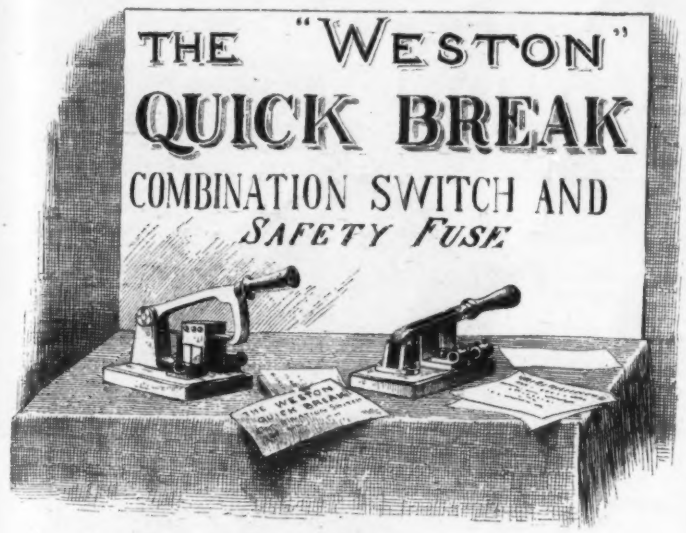
field, and the iron molecules would in the aggregate behave almost like the motionless transmitters of other substances. The consequences of this conception seem more complex even if more nearly true.

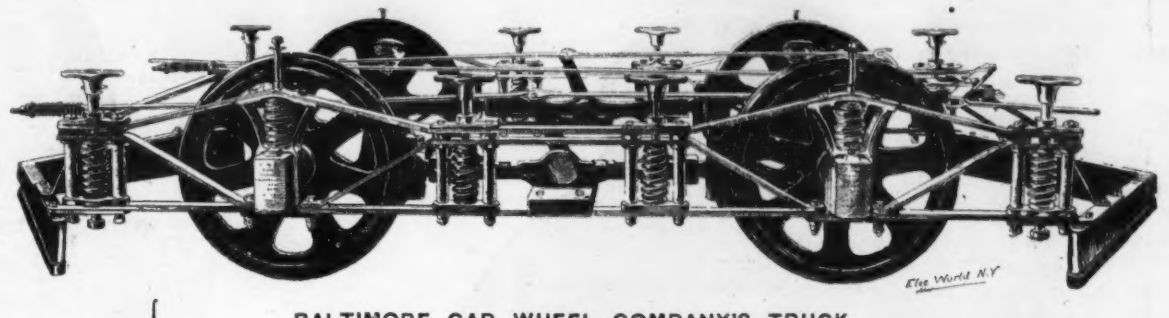
Turning now to the descending curve of reluctivity between the initial and critical values, closer examination will show that here at least the linear relation is only an apparent one. The descent is so steep that on the scale of projection it appears nearly straight, but when magnified it has a distinct curvature. Rayleigh* and others have shown that for very small degrees of H the permeability commences with a definite steady value, and this being the case it would be impossible for the reluctivity—the reciprocal of that permeability—to be linear toward H. Series of observations covering with sufficient detail the range of H from zero to unity are apparently few, and Fig. 9 gives the plotted values of the reluctivity on an enlarged scale observed by the writer for a sample ring of Norway iron. The descending line has a marked curvature approximately logarithmic, that would be almost inappreciable, however, on the scale of the other reluctivity diagrams.

Even, however, if we admit that there exists a linear relationship between H and ρ beyond the critical point, that is to say if the experimental results justify the belief that Frölich's formula is not merely an empirical one, we are scarcely entitled to attribute to this relationship an intrinsic physical signification. It may enable us to grasp the salient features of the magnetic circuit by the re-establishment of Ohm's law, but the relationship is more likely to be the consequence of a more remote fundamental agency than to be significant of any physical condition resident in metallic reluctivity itself. This is for the reason that the increase of flux under M. M. F. in a magnetic circuit due to the presence of iron is probably owing to an assisting M. M. F. set up in that iron under stress than to any change in the latter's reluctance, and the removal of the initial source of M. M. F. from the circuit still leaves some M. M. F. active as residual magnetism.

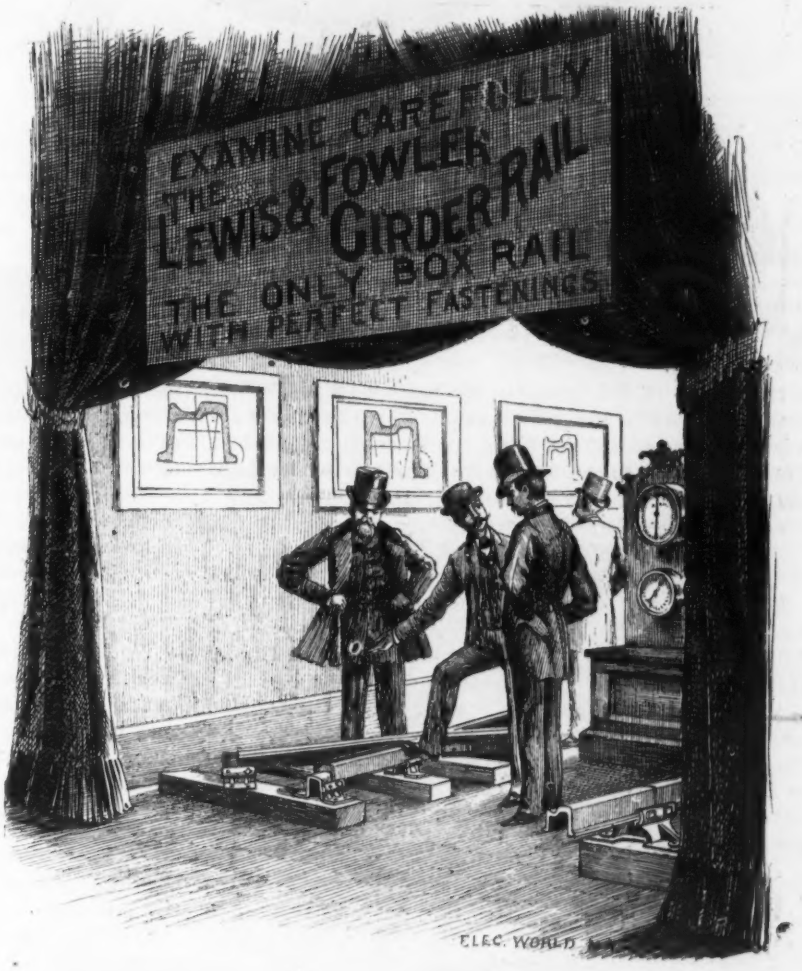
The case is similar to that of an electric circuit containing a polarizing electrolyte. It might be more simple to ignore the counter E. M. F. of polarization and to regard the resulting diminution of current as the result of an extra resistance whose value might be tabulated or possibly even reduced to simple laws. So again in alternate current circuits it is often more convenient to speak of a resistance coil with inductance as possessing an impedance greater than its ohmic resistance and to determine the flow of current on the basis of impedance calculated to the original E. M. F., whereas the direct and fundamental method would be to keep the resistance at its true value and determine the current by allowing for the counter E. M. F. of inductance in quantity and in time. We may say, then, that flow in an electric circuit is subject to Ohm's law simply when the E. M. F. is constant, but when the effective E. M. F. varies periodically the resistance has to be increased by a definite amount depending on the inductance and the manner of fluctation in order to obtain the correct effective current under those conditions. Similarly that the flux in a simple magnetic circuit of air or vacuum is subject to Ohm's law, but that if the circuit includes a magnetic metal the reluctance in the formula has to be changed in a definite way depending on the quality of the metal and on the magnetizing force in or to obtain the corresponding true flux density. The change in reluctance is the ideal connection of a shunt metallic circuit in parallel with the air circuit, and the reluctivity through the metal is nearly $a^1 - b^1 H$ for values of H below the critical and $a + bH$ for values beyond, with a little uncertainty in the vicinity of the critical point itself.

* *Phil. Mag.*, March, 1887.





BALTIMORE CAR WHEEL COMPANY'S TRUCK.



CAR HEATING APPARATUS
The CARPENTER ELECTRIC
HEATING MANUFACTURING Co.
GENERAL OFFICE & FACTORY
Cor St PETER & EXCHANGE & 40 EXCHANGE St.
ST. PAUL MINN.

SOME OF THE EXHIBITS AT THE PITTSBURGH STREET RAILWAY CONVENTION.

Railway Convention Exhibits.

In addition to the illustrations of the exhibits given last week those on this page will give our readers a general idea of the appearance of some of the more prominent and very creditable displays made by the principal railway supply houses in various parts of the country.

The Wightman Glass Insulator.

A trolley line insulator made of glass was described in THE ELECTRICAL WORLD of Oct. 24. The article stated that glass would have been earlier adopted for trolley line insulation had any one devised a practical plan of connection between the trolley wire and span wire, in order to secure the glass insulator against breakage. The Wightman Electric Manufacturing Company, of Scranton, Pa., has been manufacturing a trolley wire insulator for the past two years, in which glass is used, and has found the same to meet all requirements. A cut of this insulator appears in this issue. It has been on the market for nearly two years, and from the many testimonials which have been received in regard to its efficiency, it would seem that a "practical plan" for protecting the glass against breakage has been secured in this insulator.

THE WIGHTMAN GLASS INSULATOR.

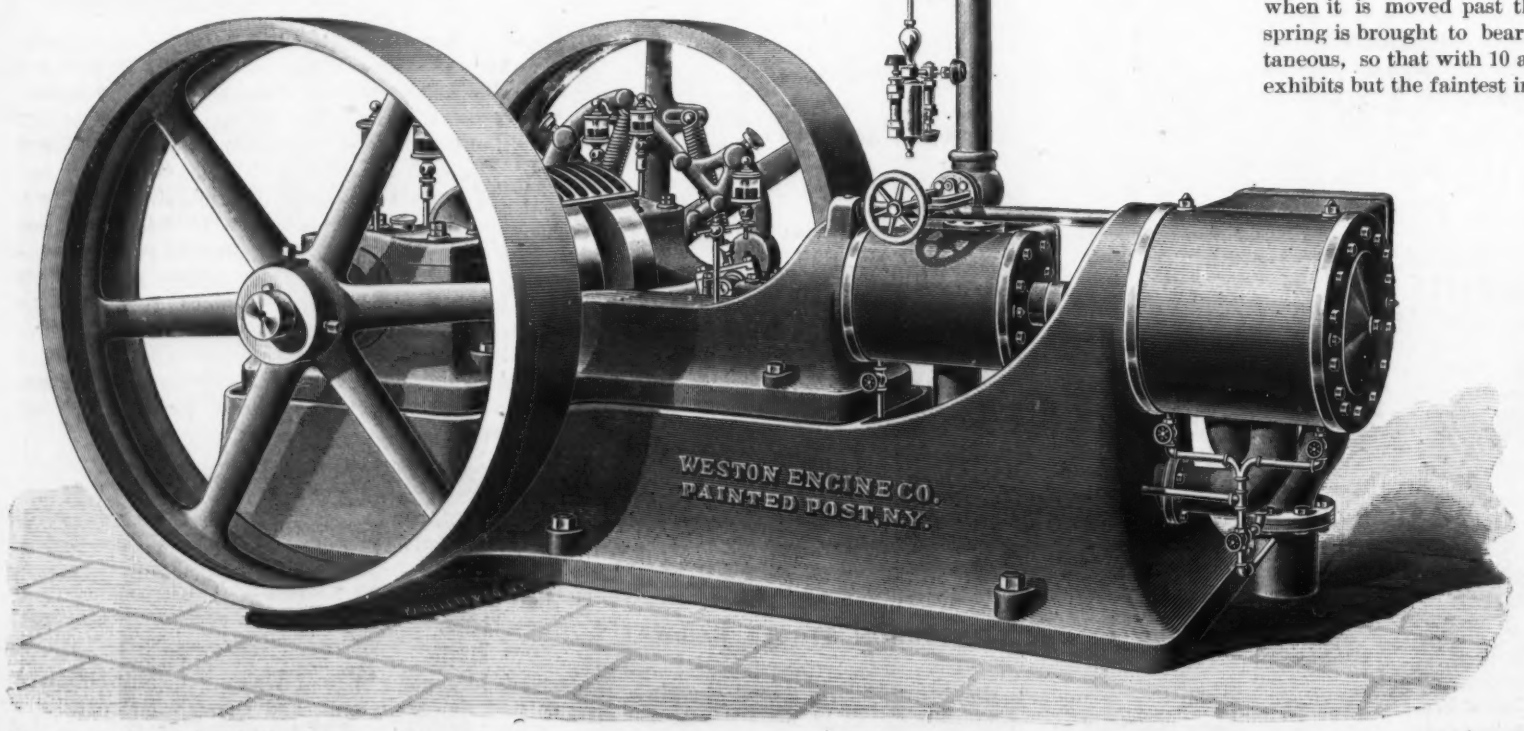
The Weston Compound Engines.

The accompanying illustration shows the Weston compound engine built by the Weston Engine Company, of Painted Post, N. Y., and handled in New York City by Julian Scholl & Co., 40 Cortlandt street.

As will be seen, the sub-base is made a part of the engine proper by extending it and projecting a neck in front of the high pressure cylinder for the attachment of the large or low pressure cylinder. This arrangement has several advantages, principal among which is the accessibility of the low pressure cylinder for inspection. As leakage from this cylinder represents the most serious loss, it is obvious that the usual practice in tandem compounding of making the low pressure cylinder practically inaccessible is a mistake, as if no opportunity is given for examination of the piston the loss from this item may in some cases be very large. As it is arranged in the Weston engine there is every opportunity for inspection. Another advantage of this form is in the total elimination of cylinder vibration, indicating great rigidity and securing permanent alignment.

These engines have a balanced four admission valve on each cylinder, and both valves are attached in a direct manner without rocker arms to the automatic governor, thus keeping the load about evenly divided between the two cylinders. This has decided advantages, for owing to the variation of load constantly occurring in some lines of service, such as electric lighting, electric railway, rolling mill work, etc., the hand adjustment is of little value, as the engine must be set for the entire run before starting to the maximum load that may be thrown on during the run, and as the actual load is considerably less during most of the time the vital feature of compounding is destroyed; whereas with the automatic attachment to each valve, the engine is always in condition to take care of any load within range of its capacity, and without disturbing any of the essential elements of compounding.

This feature of two automatic valves must be well received under any circumstances, and where strict economy of fuel is necessary its use is imperative.



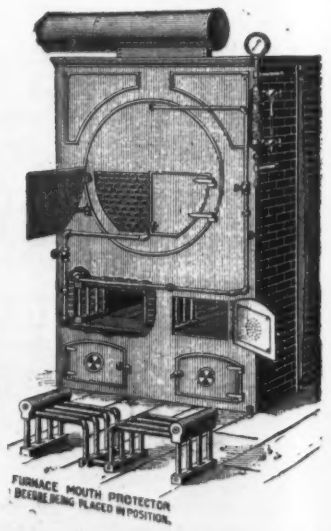
THE WESTON TANDEM COMPOUND ENGINE.

The Lamphrey Furnace Mouth Protector.

We illustrate herewith a novel protection for the brickwork in the furnace mouth which not only preserves this but acts in the capacity of a feed water heater. The water may be taken from an ordinary heater and made many degrees hotter by passing through the protector into the boiler. The Lamphrey Boiler Furnace Mouth Protector Company, No. 15 Main street, Cambridge, Mass., is the manufacturer.

The protector is having a very large sale, since engineer know by dear experience the expense and trouble incident to replacing boiler brickwork, and that this may be done away with is a matter of no small moment to them.

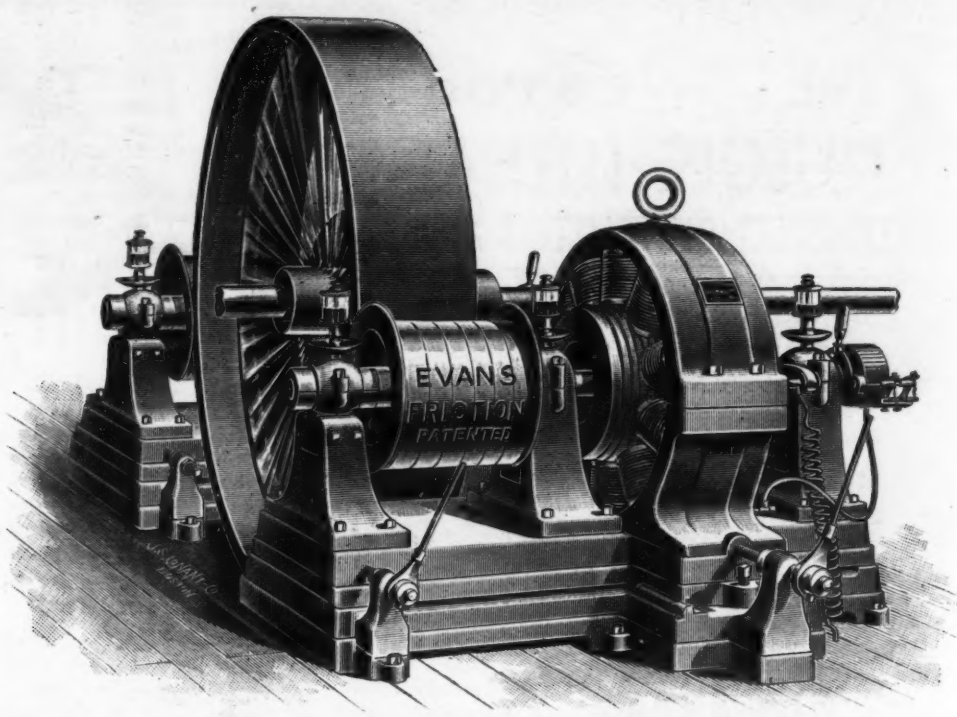
Among the orders received from electrical companies are the Cambridge (Mass.) Electric Light Company, Peabody (Mass.) Electric Light Company, Somerville (Mass.) Electric Light Company, as well as the Edison General and Edison Illuminating companies of New York.



FURNACE MOUTH PROTECTOR.

A Lighting Plant Operated by Evans Friction Cones.

The space to be occupied by an electric light plant is often so limited that anything saved in the distance between the dynamo and engine is of considerable importance to the owners of the plant. A very compact lighting plant operated by Evans friction cones is shown in the accompanying illustration, which represents two 650-light dynamos manufactured by the Thomson-Houston Electric Company. These machines are being installed for the Clinton Gas Company's electric plant at Clinton, Mass. The arrangement is a new one which provides a third bearing for the dynamo armature shaft outside of the pulley, as will be readily seen by the illustration.



THE EVANS FRICTION CONES IN A LIGHTING PLANT.

The Cutter Incandescent Switches.

A new departure in incandescent switches is soon to be offered to the trade by the Cutter Electrical and Manufacturing Company, of 27 South Eleventh street, Philadelphia. In the accompanying illustrations Fig. 1 shows the switch "open" while Fig. 2 shows it "closed." The switch is of the single pole double break class with the brushes and switching mechanism mounted upon a porcelain base, which is in turn inclosed in a casing of the same material. The copper terminal brushes are set one over the other, the distance between them being $\frac{7}{16}$ of an inch, the end of the switch bar acting as a bridge between them when the switch is closed, and giving a break of $\frac{1}{4}$ inch on each side when open. The switch bar is operated entirely by a flat semi-elliptical spring which acts eccentrically so that, until the switching lever brings the spring to the centre, there is no movement whatever of the switch bar; consequently when it is moved past the centre the full tension of the spring is brought to bear for the break, which is instantaneous, so that with 10 ampères current this size of switch exhibits but the faintest indication of a spark.

The working parts are of hard brass plate put together in a substantial manner; but perhaps the most striking feature of the device is the fact that it is operated by two push buttons set into a face plate which is set in place flush with the wall or surface of the switchboard, the porcelain case containing the switch mechanism being recessed into the wall, so that nothing is presented to view but the face plate, which may be so ornamented as to correspond with its surroundings.

One of the push buttons is white, the other black. By pushing the white one the circuit is closed, while by pushing the black one it is opened, and in case the light governed by a particular switch is in a distant room, the condition of that light as to whether it is "on" or "off" is indicated by the relative positions of the push buttons. If the white button is flush with the surface of the face plate the light is "on;" if the black one is thus flush with the plate, the light is "off."

The peculiar construction of this switch permits of an exceedingly convenient method of placing a number of switches on the same face plate, in a manner similar to that adopted in electric gas lighting. For instance, a gang of 10 switches would exhibit only a face plate 15 inches long by

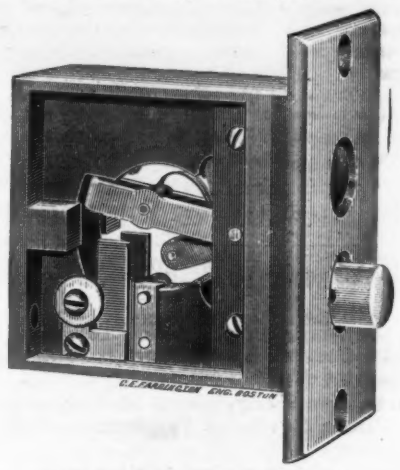


FIG. 1.—THE CUTTER SWITCH.

three and one-quarter inches wide. The switch is also modified so as to be able to control one or more lights from two or more places.

The Imperial Battery.

This battery, which is illustrated in this issue, is an improved form of the multiple, and is intended principally where an exceptionally high grade of battery is wanted on general hard work, such as telephone service. In develop-

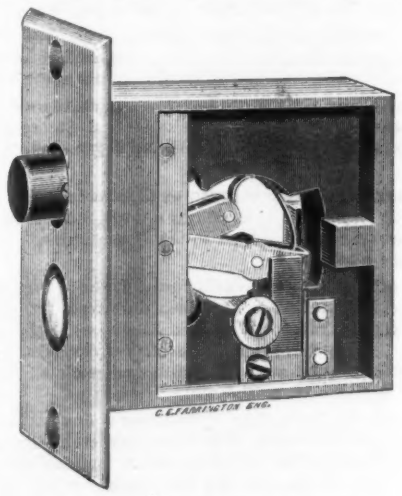


FIG. 2.—THE CUTTER SWITCH.

ing the Imperial, it has been the aim of the manufacturers to produce a battery that would meet all requirements in regard to strength, durability, recuperative qualities and long life, regardless of cost.

In this battery there is by actual measurement 196¼ square

THE IMPERIAL BATTERY.

inches of available carbon surface below the fluid line exposed to chemical action. This surface is placed in such a manner that the internal resistance of the cell is cut down to the lowest possible minimum. The entire outer cell of this battery is made of carbon, dispensing with the glass jar, the outer cell serving the double purpose as a negative exciting element of the battery and also as a retaining vessel. There are eight inwardly projecting ribs of carbon extending over the inner surface of the cell pointing toward the centre and surrounding the zincs on all sides.

The advantages claimed for the Imperial Battery are that it exposes a very large amount of carbon surface to chem-

FIG. 1.—THE IMPERIAL LAMP SOCKET.

ical action and is very effective on that account. It is manufactured by the Nowotny Electric Company, of Cincinnati, Ohio.

A New Lamp Socket.

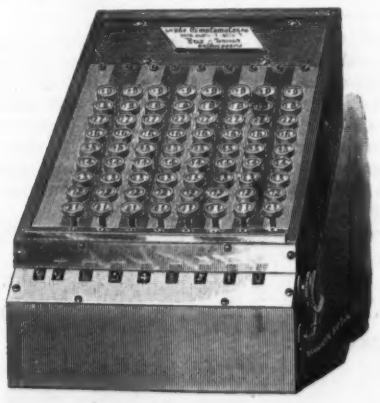
The accompanying illustration shows a socket just placed upon the market by the Imperial Electric Company, of 1,218 and 1,220 Filbert street, Philadelphia. The insulation

FIG. 2.—THE IMPERIAL LAMP SOCKET.

of the socket is made entirely of porcelain, so as to avoid as far as possible any trouble arising from either heat or moisture. The particular advantage, however, claimed for the socket is that it is very readily wired, and for that reason is especially adapted to chandelier and fixture work. The design of the socket is simple, and when finished has a very neat appearance.

The Comptometer.

The accompanying illustration shows this machine, which is a universal calculator, useful in business and



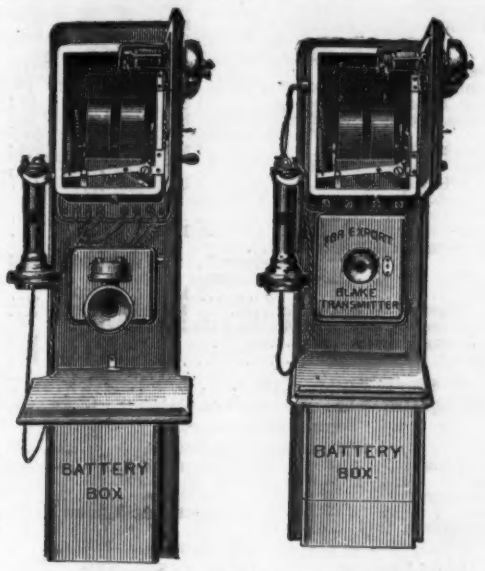
A NEW COMPTOMETER.

mathematical work. It is operated by keys like a typewriter and is destined to become an important factor in the world of accounting and scientific computation. It is a mechanical substitute for the gray matter of the brain in computing all arithmetical problems. It is now in practical use in hundreds of counting rooms in mercantile houses and in the offices of three governments, and also at a great many of the observatories in different parts of the world and is the first machine ever invented which will perform multiplication, division, extract square root, compute interest, etc., by the simple operation of automatic keys, or which will add several columns at a time.

It has recently been used in figuring out the total number of feet in several hundred coils of wire, as the wire was unloaded from the car, and also in reducing the total lengths to miles; with its aid any given number of watts can be divided by 746 in one-half the time required with paper and pencil. The comptometer is manufactured and is for sale by the Felt & Tarrant Manufacturing Company, of Chicago.

New Telephone Sets for Export.

The illustrations show the form of the new telephone sets for export manufactured by the Tropical American Tele-



NEW BELL TELEPHONE SETS.

phone Company, of Boston. The form and construction of the sets manufactured by this company have been changed from time to time to embody new ideas and suggestions. They are made with or without platinum non-corrosive contacts, with long or strong automatic hooks and with several late improvements. They are now sold outright for export.

New Electric Cut-Off Device.

This safety electric cut-off, as shown by the illustrations, consists of an electromagnet through which the current

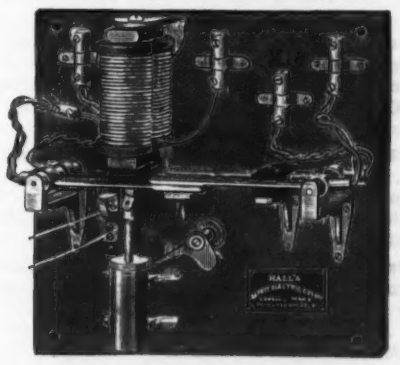


FIG. 1.—THE HALL CUT-OFF.

passes from a dynamo into levers brought in contact, through which a working current passes, and is so arranged that when the current fails the united levers fall apart, thus breaking the line in two places. It frequently happens that the current, although not totally failing, is partially interrupted, causing flashing of the lights, or variation of current employed for power purposes. While this cut-off is very sensitive in movement, it is so constructed that it prevents the opening of the line unnecessarily in such instances. It will be seen that the cross bar which connects the levers near their free ends is also connected by a link to the piston rod of a dash pot, the upper end of the link being pivoted as shown. The lower end of the piston rod is fitted with a plunger working in a dash pot, partly filled with glycerine, which slightly retards the movement of the falling lever when the circuit is opened.

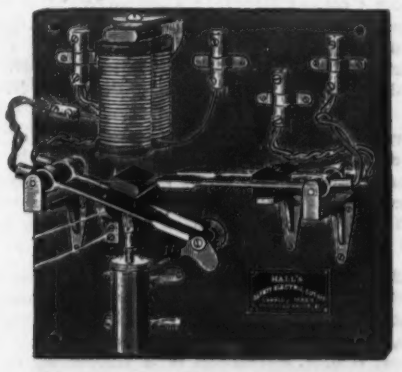


FIG. 2.—THE HALL CUT-OFF.

This apparatus is the invention of George L. Hall, an electrician of Lowell, Mass. A Lowell company, to be known as the Patent Electric Cut-Off Company, is now being formed to manufacture and introduce the appliances. Messrs. E. G. Baker, George L. Cady, and L. I. Fletcher are interested in this company.

Financial Intelligence.

THE ELECTRICAL STOCK MARKET.

The Closing Quotations of electric stocks on Saturday, Oct. 31, 1891, in New York and Boston were:

Name of Stock.	Par.	Capitalization.	Bid.	Ask'd.
Western Union Telegraph Co	100	86,200,000	82½	82⅞
American Telegraph & Cable	100	14,000,000	....	80
Central and South American	100	5,000,000	....	....
Mexican	100	2,000,000	..	....
Commercial Cable Co	100	7,716,000	.	....
Postal Telegraph Cable	100	5,000,000	28	33
Edison General Electric	100	15,000,000	98	98½
Consolidated Electric Light	100	2,500,000	20	30
Edison Illuminating Co	100	4,500,000	80	81
United States Electric Light	100	1,500,000	20	25
Edison Illuminating Co., Brooklyn	100	750,000	76	80
" " " Boston	100	1,263,500	97½	102½
" " " Chicago	100	750,000	135	145
U. S. Illuminating Co	100	1,250,000	30	35
North American Phonograph Co	...	...	1	3
New York Phonograph Co	100	6,200,000	2¼	4
Edison Elec. Light Co. (of Europe)	stock. 100	2,000,000	2½	5
" " " "	bonds	50,000	65	75
" Ore Milling Co	100	2,000,000	17½	22½
" Toy Phonograph Mfg. Co	10	1,000,000	½	1
U. S. Electric Light Co	100	1,500,000	....	20
Brush Illuminating Co., of New York	50	1,00 ,000	40	50
Mt. Morris Electric Light Co	...	500,000	....	60
East River Electric Light Co	100	1,000,000	...	60
Thomson-Houston Electric Co	25	6,000,000	45	46
" " preferred	25	4,000,000	24½	25
" International Electric Co	100	1,000,000	....	200
Thomson Electric Welding Co	100	1,000,000	....	150
" European Electric Welding Co	100	1,500,000	....	60
Westinghouse Electric Co	50	7,000,000	13½	14
Fort Wayne Electric Co	25	4,000,000	12½	13

Chicago Quotations.—Col. S. G. Lynch, broker, 153 Monroe street, Chicago, furnishes quotations on electrical stocks as follows:

TELEPHONE STOCKS.

Chicago	$212@ $220	Cumberland	$60@ $62
Central Union	50@ 51	Wisconsin	118@ 120
Michigan	82@ 83	Bell of Missouri	175@ 180
Great Southern	30@ 32	Iowa Union	20@ 22
Colorado	34@ 36	Missouri and Kansas	54@ 56
Rocky Mountain Bell	40@ 43		

ELECTRIC LIGHT STOCKS.

Chicago Arc Light and Power	$97@ $99	Chicago Edison Co	$145@$150

NEW INCORPORATIONS.

Latrobe, Pa.—The Latrobe and Derry Electric Street Railway Company has been incorporated; capital stock, $40,000. President, John W. Hughes, Latrobe; directors, John B. Miller, James E. Heck, David J. Bush and C. O. Slater.

Heisler Electric Company, of Gloucester, N. J., with a capital stock of $250,000, has been formed to manufacture and sell electric apparatus. W. Shaphigh. of Camden, N. J.; J. Ball and F. H. Morris, both of Philadelphia, Pa., are the organizers.

The Gray Electric Company, of Chicago, Ill., with a capital stock of $100,000, has been formed to manufacture, sell and use telautographs, electrical and other instruments and applhances. Elisha Gray, Fred. W. Cushing and Leon O. McPherson are the organizers.

The Atlantic Electric Light and Power Company, of Atlantic City, N. J., with a capital stock of $50,000, has been formed to manufacture, produce, supply and distribute electricity for electric lights. C. L Cole, H. J. Adams and C. E. Brown, all of Atlantic City, N. J., are the promoters.

The McLeod Electric Manufacturing Company, of Brooklyn, N. Y., with a capital stock of $3,000, has been incorporated for the purpose of manufacturing electrical machines, implements and specialties. James MacBeth, Jos. N. McLeod and Chas. Van Winkle are the incorporators.

The Springfield Light and Power Company, of Springfield, O., with a capital stock of $200,000, has been incorporated, for the purpose of generating and distributing electricity for light, power, etc. Allston Burr, C. H. Pierce, Jno. H. Miller, W. A. Scott and George Martin are the organizers.

The Wampa Electric Light and Power Company, of Wampa, Idaho, has been organized with a capital stock of $24,000 to construct and operate an electric plant for the distribution of light and power. J. N. Johns, P. W. Purdum, of Wampa, and H. E. Simmons, of Summit, N. J., are the incorporators.

The Europes-American Electric Incorporation, of Chicago, Ill., with a capital stock of $2,000,000, has been organized to acquire, manufacture and deal in electrical patents, inventions, devices, improvements and machinery. Frank Butterworth, Monroe L. Willard and Arthur A. Bliss are the promoters.

The Gothenburg Water Power and Investment Company (incorporated in Nebraska), of Milwaukee, Wis., has been incorporated with a capital stock of $2,500,000, to construct electric street railways, maintain a system of water-works, etc. A. H. Hadfield, M. H. Brand and Charles Quarles are the organizers.

The Lake Erie Electric Light Company, of Elyria, O., with a capital stock of $20,000, has been incorporated to manufacture electric light and gas, and to furnish the same for light, heat and power, etc. F. M. Townsend, Henry W. Worst, Sam Rawson, Chas. E. Wilson, W. L. Fay and Lester McLean are the incorporators.

The Union County Electric Company, of Roselle, N. J., has been formed, with a capital stock of $30,000, to construct, acquire, maintain, etc., works and machinery of all kinds for transmitting electricity. H. P. Baldwin, of Roselle, N. J.; H. M. Bylesby, of St. Paul, Minn., and W. H. Moore, of Plainfield, N. J., are the organizers.

The Central Electric Railway Company, of Paterson, N. J., with a capital stock of $30,000, has been organized to construct, maintain and operate a street railway. The incorporators are: E. Stevenson, W. Pennington, A. H. Post, J. A. Morrison, J. R. Beam, F. C. Van Dyk, J. Wadsworth, F. H. Crossons, A. A. Van Voorhies and G. C. Mason.

The San Bernardino Street Railway Company, of San Bernardino, Cal., has been formed, with a capital stock of $10,000, to construct and operate lines of street cars in San Bernardino by horses, mules, electricity or steam. Henry M. Willis, J. R. Brunn, James Fleming, Wm. A. Harris and W. S Hooper, all of San Bernardino, are the organizers.

The New York Electric Construction Company, of Jersey City, N. J., with a capital stock of $100,000, has been formed, to build, enlarge or complete electric light plants and electric light devices. Thos. H. Howell, John H. Hapgood, Peter B. Vermilya and Geo. E. Hutchinson, all of New York City, and Chas. S. Van Nuis, of New Brunswick, N. J., are the incorporators.

The Columbus and Westerville Railway Company, of Columbus, O., has been organized, with a capital stock of $100,000, to construct and operate a street railroad between Columbus and Westerville, Franklin County, O., to be operated by electricity or other power. M. H. Neil, Lewis Huffman, A. G. Innis, G. W. Williams, G. W. Meeker, F. H. Houghton, J. W. Everal, E. H. Reasoner and C. E. Bell are the incorporators.

AFFAIRS OF THE COMPANIES.

Princeton, Ill.—It is stated that the Princeton electric light plant has been sold to a local syndicate.

Lafayette, Ind.—The W. D. Hyslop Electric Company has succeeded the Lafayette Electrical Company.

Middletown, O.—The Middletown and Madison Street Railroad Company has increased its capital stock from $10,000 to $50,000.

San Francisco, Cal.—The Edison Light and Power Company has filed a certificate in regard to increasing its bonded indebtedness of $800,000 by issuing 800 bonds, payable in 30 years at six per cent. per annum interest.

Nashville, Tenn.—At a recent meeting of the Nashville Electric Railroad and Power Company, Samuel H. Pearcy resigned as superintendent, and George K. Whitworth, as treasurer. Mr. John N. Brooks was elected treasurer.

Ottawa, Can.—It is stated officially that Messrs. Ahern & Soper have purchased the interest of Mr. T. C. Keefer in the Ottawa City Passenger Railway Company, and that the lines will be equipped with electricity as soon as practicable.

Lowell, Mass.—The executive committee of the Erie Telegraph and Telephone Company, at a recent meeting, recommended to the directors that the quarterly dividend of one per cent. be declared payable Nov. 16 to stockholders of record Nov. 7.

Sold to the Villard Syndicate.—The West Side Street Railway lines of Milwaukee, Washington Becker's electric road, were sold Oct. 31 to the Villard syndicate for $875,000. The sale was made through the Central Trust Company, of New York.

Princeton, Ill.—At a recent meeting of the Princeton Electric Light Company, the following officers were elected: President, W. F. Horton; vice-president, H. H. Ferris; secretary, F. W. Clark; treasurer, Fred Horton; superintendent, Will. J. Kendall; engineer, Albert Sadler.

Santa Fe, N. M.—The Santa Fe Electric Company will hold its annual meeting this month for the election of officers. It is contemplated to enlarge the plant, and at the annual meeting it is stated that the stockholders will vote to bond the plant for $10,000 for improvements.

Watertown, N. Y.—The Watertown Electric Street Railway Company at its recent annual meeting elected the following officers: President, John C. Thompson, New York; vice-president, Chas. A. Starbuck, New York; secretary and treasurer, Edmund S. Goodale, of this city; superintendent, W. S. Jones.

The regular dividend of two per cent. in cash, amounting to $7,500, was paid recently on the $375,000 of preferred stock of the Great Western Electric Supply Company, of Chicago. A dividend will be paid soon on the common stock of the company, if its business continues to increase at its present satisfactory rate.

Easton, Pa.—At a recent annual meeting of the Edison Illuminating Company the following were re-elected directors for the ensuing year: John T. Knight, Nelson P. Cornell, Samuel Drake, William Laubach, Russell C. Stewart and William H. Hulick. The reports of the president and manager showed a satisfactory increase in business.

Baton Rouge, La.—At the annual meeting of the stockholders of the Baton Rouge Electric Light and Power Company O. B. Steele, R. H. Burke, Ben R. Mayer, N. Wax and A. Strenki were elected directors for the ensuing year. Ben. R. Mayer was elected president, N. Wax, vice-president; W. J. Knox, Treasurer, and Geo. Spencer, secretary.

The Otis Electric Supply Company, of Binghamton, N. Y., has been dissolved by mutual consent. Mr. Milton M. Jacobs, who has been with the company for the past four years as electrical expert, with Mr. Frank G. Writer, will carry on the business under the name of the Star Electric Company of Binghamton. The new firm reports having several large contracts under way.

The Hudson Electric Light Company, of Hoboken, N. J., has mortgaged its plant to the State Street Safe Deposit and Trust Company, of Boston. The company owed the Thomson-Houston Electric Light Company, of Pennsylvania, $90,000. To pay this debt and secure exclusive rights, the company issued bonds amounting to $150,000, which are held in trust by the trust company. The mortgage was given to secure the bonds.

Butte, Mont.—The Silver Bow Electric Light Company and the Butte Electric Light and Power Company for some time have been engaged in a conflict of interests, which has finally culminated in the union of the concerns under one management, dividing their business equally. Mr. S. H. Pierce is general manager of both companies, and Mr. J. R. Wharton financial manager. Separate books will be kept, office expenses divided, and lighting rates will be restored to the prices before the cut.

The Western Union Telegraph Company has paid over to the commonwealth of Massachusetts a disputed tax payment of $62,668. The tax covered the years 1886 to 1890 inclusive, and it was the subject of long litigation. The amount is $100 less than the statement of the attorney-general called for, this amount being the result of an error in computing interest. Besides the amount which was turned over to the treasurer, there is $7,615 more to be paid which is now in the hands of the clerk of the circuit court, which was handed to him when the case was transferred.

The Bell Telephone Output for the month ending Oct. 20 was as follows:

	1891.	1890.	Inc.	Dec.
Gross output	5,272	5,378	....	106
Returned	4,224	2,205	2,019	....
Net	1,048	3,173	....	2,125
From Dec. 21 to Oct. 20:				
	1890-91.	1889-90.	Inc.	Dec.
Gross	59,220	53,787	5,433	....
Returned	35,573	22,315	13,258	....
Net	23,647	31,472	....	7,825

Springfield, Mass.—The recent report of the Springfield Street Railway Company for the fiscal year ended Oct. 1, is an interesting showing, especially for the four months operation under the electrical system. The total income for the year was $222,531, against $188,107 for the preceding year, an increase of $34,244. The operating expenses were $179,363, an increase of $21,734 over the preceding year. The net income is $42,983 against $30,473, an increase of $12,734 for the year. The traffic shows a large increase. In considering the showing made, it should be borne in mind that the capital stock of the company has been increased from $400,000 to $650,000, $244,096 having been expended for new construction and equipment.

The Cowles Electric Smelting and Aluminium Company, of Lockport, N. Y, held its recent annual meeting in Cleveland. Mr. Eugene Cowles resigned as president, and Mr. F. W. Mathiessen, of La Salle, Ill., was elected president in his place. Mr. Mathiessen will assume the business direction of the company, and Mr. Cowles will be resident manager at Lockport. Extensive additions will be made to the plant in Lockport, and to the one at Stoke-on-Trent, England, and the capacity of the latter will be capable of producing 20 tons of aluminium per day, requiring about 30,000 h. p. The new officers of the company are F. W. Mathiessen, president; vice-president, Alfred H. Cowles, of Lockport; secretary, Horace W. Power, of Cleveland; treasurer, A. F. Osborne, of Cleveland.

Thomson European Electric Welding.—The Boston *News Bureau*, of Oct. 28, had the following in regard to this company: The Thomson European Electric Welding Company was brought out in England about a month ago. Enough shares were taken by the public and the underwriters to carry on operations, and the transfer will be made Saturday, Oct. 31. The Thomson European Electric Welding Company transfers all rights and patents in England and receives the final sum of £20,000 cash, including blue prints and patents. The London Contract Company has paid £82,098 and on Saturday next will pay in common shares £83,330 and £4,000 in founders' shares; £3,500 has already been paid for electric welding machines, and on Saturday £20,000 will be paid in cash. The net amount of this £102,098 received is on deposit in bank in Boston and is sufficient to pay all operating expenses. The company has left the patents of Continental Europe and the above-named shares as treasury assets. An agent leaves to-morrow to promote the company's interests on the Continent.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-177 TIMES BUILDING, NEW YORK, Nov. 2, 1891.

Mr. Elias E. Ries, of the Ries Electric Specialty Company, of Baltimore, was in the city last week.

Mr. Chas. G. Armstrong, the well known electrical expert, of Chicago, called at the office of THE ELECTRICAL WORLD last week.

The International Portelectric Company, of which Mr. J. B. Williams is general manager, has opened an office in the Electrical Exchange Building.

It is stated that Henry Villard and Jay Gould have an understanding, through which Mr. Gould is to join with Mr. Villard in the latter's electric schemes.

Mr. M. J. Sullivan, the well known advertising agent of the Edison General Electric Company, has resigned from that position to take up newspaper work.

Mr. J. S. Ball, of the Ball Electric Light Company, Ninth avenue and Twenty-second street, reports a gratifying increase of business and a large number of orders ahead.

Mr. Eldredge Packer, formerly with the New York Car Wheel works, has accepted a position with Mr. F. D. Russell, manager of the New York office of the Rochester Car Wheel Works.

Mr. F. H. Sparling, formerly connected with W. H. Gordon & Co., is now representing John A. Roebling's Sons Company in New York State. His many friends will be glad to learn of his success.

Mr. W. S. Chesley, 136 Liberty street, reports the sale of a 50-light Thomson-Houston and a 225-light United States dynamo, a 2-h. p. Perret motor and a supply of Edison key sockets and other instruments.

A Wurzburger Nacht was given by the Electric Club Thursday evening, Oct. 29, which was attended by a large number of members and invited guests, who indulged in the "relaxation" features of the entertainment given.

The firm of Tucker & Hall, formerly doing business in the Electrical Exchange Building, has been dissolved. It will be continued at the same address, 432 and 434 Electrical Exchange Building, corner of Liberty and Washington streets, by Wm. H. Tucker, who will receive all outstanding accounts and settle all bills against the old firm.

The Dale Manufacturing Company, dealers in electric light supplies and contractors, of 90 Fulton street, has recently completed the installation of an electric plant in the factory of James G. Wilson, of Olean, N. Y. The United States system is used, capacity 280 lights. The work was done under the supervision of Mr. John H. Dale.

The Zucker & Levett Chemical Company, of 40 Murray street, has in course of construction a large new factory at 10, 12 and 14 Grand street, which the company expects to occupy about January 1. The new plant is being fitted with all the latest improved machinery and will be one of the finest factories in the country. The company report gratifying success with its new Hercules motor, an illustration of which was given in THE ELECTRICAL WORLD July 25, 1891.

The Alexander-Chamberlain Electric Company has recently been formed, with Mr. Hugo Alexander, president; Mr. Harry Alexander, vice-president and general manager, and Mr. Rufus N. Chamberlain, secretary and treasurer. This company is located at 126 Liberty street, and will do electrical construction in all its branches, making a specialty of isolated plants for private houses, stores and factories, together with an inspection system for electrical plants. The members of the firm are gentlemen well known as energetic and familiar with every detail of their business, and they will be accorded a liberal patronage.

The Engineering Equipment Company, of 143 Liberty street, has changed its quarters in the Central building. Messrs. Perrine & Crane, of this company, are meeting with the most flattering success in their business, and the recent change to more commodious quarters on the ground floor of the Central building has been brought about by an increased business, and as was recently facetiously remarked by a friend of the company, while the change may be a "come down" it gives them and their customers an opening "on the ground floor" in all that is new and in demand in electric railway, belting, wire and other specialties. N. H. 2d.

NEW ENGLAND NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
Room 28, Hathaway Building, 620 Atlantic Ave.,
BOSTON, Mass., Oct. 31. 1891.

Haverhill, Mass.—The question of using Mitchell's Falls for the generation of electric power and light is being agitated.

R. Hollings & Co., Boston, have issued a very attractive catalogue of their many beautiful and original designs of gas and electric fixtures.

The United Electric Light Company, of Springfield, will increase its plant by the addition of two 300-h. p Hazelton boilers and a 400-h. p. Armington & Sims engine.

Whitmore & Robinson, electrical engineers, are out with a very neat little work showing just the ground covered by them in making estimates, testing, purchasing, etc.

The Redding Electric Company is meeting with a very

large sale of its watchman's clock, which together with the calls for "electrix" specialties makes business pretty lively.

The American Circular Loom Company reports business as extremely brisk on its well known brand of wire, and there are many advance orders in hand for a new conduit which will be out shortly.

The Standard Fuel Company is meeting with great success with its new coal saver, "Kem-Kom." It is being used by many electric light companies as well as railways, with the result of invariably reducing coal bills to a large extent.

Taunton, Mass.—Steps are being taken for the organization of a company for manufacturing a new patent street railway car. Capitalists have already subscribed a large amount. It is proposed to raise $100,000 in order to have the plant located in Taunton.

Edward Kendall & Sons, Cambridgeport, have recently installed some large steam plants at North Adams, Lowell, Lawrence, Fall River and Providence. With their large facilities for turning out work they are severely tried at times to deliver work promptly, a point they are very particular about.

The W. S. Hill Electric Company starts in under the new management in a way that augurs well for its future success. A large number of orders have already been received. The plant of this company is being rapidly enlarged to meet the increased demand, and very soon its facilities will be second to none for the manufacture of the "Hill" well known specialties, including some decidedly new.

A Course of Free Lectures, for engineers and electricians, given by the Lowell fund, will commence this week at the Wells Memorial Institute, Boston. The course will include the following topics: Electricity, Elementary and Advanced; Steam and the Steam Engine; Sanitary Engineering and Building Construction. The lectures on electricity will be delivered by Prof. Wm. L. Puffer, of the Institute of Technology; on steam and the steam engine, by Thomas Hawley, of the Boston *Journal of Commerce;* on building construction, etc., by Prof. E. W. Smith.

The Eddy Electric Manufacturing Company, of Windsor, Conn., has recently shipped some heavy electrical machinery to Zanesville, O., for the equipping of the Encaustic Tiling Company's factory. It consisted of two 100 h. p. dynamos, weighing about eight tons each, together with two 40, one 25, two 20, three 10 and one 5-h. p. motors, making a total of 380-h. p. electric machines. The Eddy company has in its works a 120-h. p. electrical forging machine which is being built for the Krupp gun works at Essen, Germany. The Eddy plant has a capacity for building as large as 300-h. p. dynamos and employs nearly 100 hands. It is putting in solid masonry foundations under certain parts of its building, preparatory to placing new and heavy machinery, among which will be a new planer, to weigh 10 tons. C. A. B.

WESTERN NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
465 The Rookery, CHICAGO, Oct. 31, 1891.

Mr. John R. Markle, of Detroit, was in Chicago this week.

Mr. Albert Scheible read a paper before the Chicago Electrical Society this week.

Mr. J. M. Fordham, of the Benedict & Burnham Company, was in Chicago this week talking up the merits of B. & B.'s wires.

Mr. W. J. Pilley, manager of the Chicago office of the Eastern Electrical Supply Company, of Boston, is absent on a Western trip.

Mr. H. C. Bullis, formerly superintendent of the Baton Rogue Electric Light and Power Company, has become a resident of Chicago.

Ward Arc Lamps have been placed in the shops of the Chicago & Northwestern Railway at West Chicago, and at Clinton, displacing the incandescent lamps.

Mr. W. H. Miller, of the order department of Holmes, Booth & Haydens, New York, carried away some nice orders for insulated wires from Chicago this week.

President Henry M. Whitney and Chief Engineer F. S. Pearson, of the West End Railway, of Boston, were in Chicago this week en route home from Minneapolis.

Mr. P. S. Kingsland, manager of the Chicago office of the Phœnix Iron Works, recently secured the contract for the complete steam plant in the asylum at Indianapolis, Ind.

Mr. J. M. Hayes, manager of the Chicago office of C. & G. Cooper & Co., of Mt. Vernon, O., secured the order for the engines for the electric light installation at the Union Stock Yards.

The Electrical Construction Company, Franklin street, Chicago, has adopted for letter heads a lithographed representation of the electricity building of the World's Columbian Exposition.

Mr. C. B. Osgood, southern manager of the Westinghouse Electric Company's railway department, ran into Chicago from Pittsburgh for a visit of a day or two before returning to Atlanta Ga.

Mr. C. E. Gregory, general sales agent of the Standard Electric Company, of Chicago, is recovering from a severe attack of typhoid fever, which accounts for his absence from the office during the past few weeks.

Mr. B. J. Arnold returned to Little Rock, Ark., this week, where he is temporarily looking after the interests of the Trust Company in the large electric power station now nearing completion in that city.

Mr. John Young has secured the order for the electrical machinery in the Leiter Building, on State street, Chicago, and will place about 400 arc lights and 4,000 incandescent lamps of the Western electric system.

Mr. George H. Heafford, general passenger agent of the Chicago, Milwaukee & St. Paul Railway Company, Rand-McNally Building, Chicago, is distributing a handsome map of the City of Chicago, showing more particularly the site of the World's Fair.

Mr. Edward A. Sharp, clerk of the village of Rogers Park, a suburb of Chicago, is calling for bids for lighting the streets of that village with about 40 arc lights of 2,000 c. p., it being understood that a franchise will be immediately granted to the party to whom the contract is given.

Mr. W. C. Lyman, of 49 Michigan street, Chicago, reports an active demand for the Lyman exhaust head from electric stations, sales for September and October being far in excess of any other two months of this or former years. A large amount of Lyman's improved exhaust piping has also been sold.

Mr. Carl Kammeyer, superintendent of the National Electric Manufacturing Company, of Eau Claire, Wis., is in Chicago closing contracts for additional apparatus. Mr. Kammeyer is preparing an important paper on the subject of "Fuses" which he has been invited to read before the Chicago Electric Club in December.

Mr. George Cutter's latest development is a "petite pulley,' which is a smaller form of his well-known lamp supporting pulley. It is intended for use with incandescent lamps, and will find a market wherever lamps are suspended over street crossings. Mr. Cutter has also been booking large orders for Simplex rubber wire and for rubber insulated screwdrivers.

Albert J. Dexter, a physician, of Chicago, has entered suit in the United States Circuit Court for $50,000 damages against George Henckel, the inventor of an electric device called a cavascope, for lighting up the throat or cavities in any portion of the body for close inspection. Dexter purchased the patent and claims that the device is not what the patentee claimed it was.

J. J. Ryan & Co., the extensive brass foundry men of Chicago, are sending out some aluminium brass castings weighing from 300 pounds to 600 pounds, for use in elevator work and in mining service. They are also making aluminium and brass castings for electric railway and supply companies, who have paid them many compliments for the superior finish of their work.

J. Lang & Co., of 44 Michigan street, Chicago, are running their factory to its full capacity in order to supply Andrews switches to various supply and construction companies. When these switches are manufactured for specially designed switchboards, the copper conductors are joined or "sweated" on the back of the switch, no wire showing in front, thus saving space and enabling a greater number of switches to be placed on a given frame and also making a much neater job. Conductors ranging in size up to one inch or more are now being joined to the additional switches required for the Fair building.

Mr. Geo. H. Meeker, Western manager of the New York Insulated Wire Company, 378 Franklin street, Chicago, has received the first of a shipment of three carloads of Grimshaw white core and B. D. wires from the factory at Wallingford, Conn. In this shipment is one million feet of the well known trade numbers 228 and 327, No. 14 B. & S. wire, or more than enough to reach in a straight line from Chicago to Davenport, Iowa, and the total shipment, if strung on poles, would nearly reach across the United States. The satisfactory success that this company has made with its goods since opening the Chicago store has warranted such shipments. Its Vulca wire ducts are about to be installed in the new Masonic Hall, at Utica, N. Y., and are being extensively used throughout the West.

An Electrical Manufactory.—At Idlewild, Ill., two miles south of Highland Park and on the west side of the Northwestern Railway, the factory of the Gray Electrical Company, of which Prof. Elisha Gray is president, will be erected at once at a cost of $30,000. The building is to be 60 x 140 feet and three stories high. It is expected that the factory will be in operation about April 1. It is the intention of the company to manufacture all varieties of electrical apparatus permissible under the patent laws, but the chief object will be to manufacture the telautograph instrument, which is an invention of Prof. Gray, the introduction of which, it is claimed, will simplify and facilitate commercial transactions by telegraph. One hundred men will be employed, especially those skilled in the manufacture of electrical apparatus. F. DE L.

LINCOLN, Neb., Oct. 28, 1891.

The City of Crete, Neb., contemplates the purchase of a larger arc machine.

The County Hospital, Omaha, Neb., is receiving bids for incandescent lighting.

The Lincoln City Electric Railway Company has gone into the hands of a receiver.

The City Hall at Omaha is to be lighted by electricity. The work is progressing rapidly.

The Lincoln Incandescent Lamp Company is contemplating removing to Waukegan, Ill.

D. E. Thomson, President of the Lincoln Electric Light Company, is on a business trip to Chicago.

The Lincoln Electric Light Company has installed a new 1,000-light National electric dynamo.

The Lansing Opera House is being wired by the Lincoln Electric Manufacturing Company for 1,134 16-c. p. lights.

The Following Central Stations contemplate an increase of alternating apparatus: West Point, Norfolk and Beatrice, Neb.

Wilber, Neb., is to have electric lights soon. The Lincoln Electrical Manufacturing and Supply Company will put in the plant.

The Lansing Opera House, at Lincoln, Neb, will have an electric elevator, which has been purchased from the Hale Electric Elevator Company.

At the Peru, Neb., Normal School a Mayo incandescent plant has recently been installed by the Lincoln Electrical Manufacturing and Supply Company.

Mr. W. Mandeville, manager of the Kearney Electric Light Company, is about to resign his position with the company, having accepted an offer from the C. & C. Motor Company. H. A.

News of the Week.

THE ELECTRIC LIGHT.

Kewaskum, Wis.—The town is to have electric lights.

Manson, Ia.—The contract has been let for electric lights.

Canton, S. Dak.—The city has contracted for electric lights.

Bremen, Ind.—The question of electric lighting is being agitated.

Aurora Springs, Mo.—The city has voted in favor of electric lights.

Elk Rapids, Mich.—Citizens are talking in favor of electric lights.

Moorhead, Minn.—The town has decided to put in electric lights.

Homer, Ill.—Citizens are considering the question of electric lighting.

Prospect Harbor, Me.—The electric light plant has been completed.

Denison, Ia.—The town is considering putting in an electric light plant.

Schuylkill Haven, Pa.—The electric light plant has been put in operation.

Brenham, Tex.—The McFadden Compress Company is installing an electric plant.

Xenia, Ind.—The question of a municipal electric lighting plant is being agitated.

Homestead, Pa.—The town has an electric light plant and furnishes 44 arc lights.

Rock Falls, Ill.—The project of a municipal electric lighting plant is being agitated.

Riverside, Ill.—It is expected that the electric lighting plant will soon be in operation.

New London, Wis.—It is expected that the electric light plant will be in operation Dec. 1.

West Duluth, Minn.—The West Duluth Electric Company has added a new arc machine.

Gibson City, Ill.—A move is being made to have electric lights in the town within a short time.

Merrill, Wis.—The Gilkey & Anson Company has installed an electric lighting plant in its mills.

New London, Wis.—It is expected that the electric light plant will be in operation by Dec. 1.

Pittsburgh, Pa.—The question of the city's running its own electric light plant is being agitated.

Canton, Ill.—The People's Gas and Electric Light Company is putting in an incandescent system.

Van Buren, Ark.—The Long-Bell Lumber Company is installing an electric lighting plant in its mill.

Owosso, Mich.—The Owosso Electric Light Company is adding a new engine and boiler to its plant.

Lansing, Mich.—E. Bement & Sons have installed a 450-light Edison incandescent system in their factory.

Mascoutah, Ill.—The Mascoutah Electric Light Company expects to have its plant in operation by Dec. 1.

Pecatonica, Ill.—The electric light and power company has recently added a new incandescent machine.

THE ELECTRIC RAILWAY.

Erie, Pa.—An electric road between Erie and North East, a distance of 13 miles, is being agitated.

Pittsfield, N. H.—The West End Electric Railway Company has commenced operating its lines.

Shelby, N. C.—C. W. Gallagher, of Baltimore, it is stated, is organizing a company to build an electric line from Shelby to the Cleveland Springs.

Aspen, Col.—It is stated upon the authority of Mr. T. J. Flynn that work will be commenced upon an electric street car line in Aspen early in the spring.

Old Point Comfort, Va.—Work on the electric street car line to Mill Creek is being rapidly pushed, with prospects that the line will be completed by Dec. 1.

Watertown, N.Y.—The directors of the Watertown Electric Street Railway Company at a recent meeting voted to order a new dynamo to supply increased power for the road.

Cicero, Ill.—The Committee of the Town Board, to which was referred the matter of the Cicero and Proviso electric railway extension, reported in favor of granting the extension.

Waltham, Mass.—The cities between Waltham and Boston are agitating the building of an electric street railway to connect the two places and also accommodate Newton and Watertown.

Westbrook, Me.—The Portland Railroad Company has petitioned the selectmen of Deering for permission to extend its tracks to that place. A hearing will be given Nov. 11. If permission is granted, work will begin at once.

Middletown, Pa.—The new electric railway which is to be constructed will be known as the Middletown, Highspire & Steelton Passenger Railway. The company has been granted right of way, and the survey of the proposed route will be made at once.

Brookfield, Mass.—A committee consisting of H. E. Capen, C. L. Ellis and H. P. Gerald, has been appointed by the Board of Trade to confer with the directors of the Worcester, Leicester and Spencer road, with a view to having them extend their system to Warren with a power house at Brookfield. It is stated that in case of failure to make an agreement it is proposed to organize a corporation for the purpose in the spring.

Du Bois, Pa.—The Du Bois Traction Railway Company has recently put in operation its new electric street railway, which is 2¼ miles long. It is equipped with the Edison system and Brill cars. The company is capitalized for $85,000, and extensions are contemplated to Falls Creek. The officers of the company are: Jas. E. Lane, of Pittsburgh, president; Chas. E. Bostwick, Du Bois, secretary and general superintendent; G. E. Grier, treasurer; directors, Chas. E. Bostwick, J. A. Terpe and J. W. Grier, Du Bois; John C. Grier, Punxsutawney; Dr. C. J. Jessup, Kittanning; A. C. and J. D. Bailey, and M. D. Wayman, Ford City, and J. M. Morrison, Pittsburgh; Chas. McKee, of Pittsburgh, engineer.

Westborough, Mass.—The directors of the proposed Westborough & Marlborough Street Railroad met recently and completed the organization of the company by the election of Mr. J. A. Fayerweather as chairman, Mr. Thomas T. Robinson as treasurer, and Mr. Geo. L. Smith as clerk, these offices to be held by them until the first 10 per cent. of the capital stock is paid in and the charter obtained. Messrs. B. C. Hathaway, Geo. L. Smith, W. B. Ferguson and T. T. Robinson, of the directors, were appointed a committee to investigate the most feasible route for the establishment of a railway between Westborough and Marlborough, also to consider all matters in connection with the installation of the road. It is thought the road will be established in the spring.

GENERAL APPLICATIONS OF POWER.

Charlotte, N. C.—It is proposed to supply Charlotte with electric lights by utilizing the power from the Catawba River.

Barre, Vt.—A meeting was held recently to arrange for erecting an electric plant to furnish power for mining derricks and machinery at the quarries.

Aurora, Ill.—The Prindle Manufacturing Company has put in a 20-h. p. electric motor to run its machinery by electric power furnished by the street railway company.

Burkhardt, Wis.—Mr. C. Burkhardt, proprietor of Burkhardt's mills, has begun operations on a power plant to utilize the water power of Willow River. A power station for a complete electric plant will be put in and power will be furnished to several towns and cities in the State.

PERSONALS.

Mr. Frank P. Yenawine, of St. Joseph, Mo., has been appointed city electrician by the Common Council.

Mr. Louis Lusk, of Antigo, Wis., is to be the manager of the new electric light plant being erected at Riverside, Ill.

Mr. E. H. Waldo, of Lynn, Mass, has been engaged as electrician for the Milford, Mass., Electric Light and Power Company, to succeed Mr. G. B. Coleman.

Mr. George H. Poor, formerly manager of the Boyer Railway Speed Recorder Company, has been elected general manager of the W. S. Hill Electric Company, of Boston.

Mr. Wm. L. Scott, well known as the president of the St. Louis Electrical Supply Company, died recently, aged 52. He was a gentleman of great executive ability and highly esteemed by all who knew him.

Capt. Samuel H. Pearce, who recently resigned as superintendent of the Nashville, Tenn., Electric Railroad and Power Company, will leave this month for Balboa, Spain, where he will build an electric street railroad.

Mr. G. I. Goodenow, of Kalamazoo, Mich., has resigned as secretary and manager of the City Electric Light Company, and will engage in the electrical business, installing isolated plants for power and lighting and furnishing electrical supplies.

LEGAL NOTES.

A petition has been filed in the Supreme Court for the dissolution of the Middleboro (Mass.) Light and Power Company.

Nevada, Mo.—A St. Louis trust company has been enjoined from foreclosing a $12,000 mortgage on the Nevada Gas and Electric Light Works.

San Antonio, Tex.—Mr. L. M. Gregory has been appointed receiver of the Alamo Electric Company. The company operates about 20 miles of road in San Antonio.

A Receiver is to be asked for the Pine Bluff Water and Light Company, of Pine Bluff, Ark. It is stated that the bonded indebtedness of the company is between $2,000,000 and $3,000,000, and all the large bondholders willbe represented in the proceedings for a receivership.

Bills of Complaint have been filed by the Bell Telephone Company and the Metropolitan Telephone and Telegraph Company in the United States Circuit Court in New York in suits brought against Samuel H. Kissam, Henry A. Whitney and E. R. Washburn for infringements of patents.

Suit has been brought by the Thomson-Houston Electric Company in the United States courts against the Electric Merchandise Company, of Chicago, to enjoin an alleged infringement of patents for overhead conductors and switches for electric railways. An injunction restraining the use and manufacture of the devices is asked.

Sequestration Proceedings were taken recently by Lewis May, judgment creditor, to the amount of $83,580.58 against the North American Underground Telegraph and Electric Company, of New York, and upon his application Judge O'Brien, of the Supreme Court, has appointed Alva Trowbridge, cashier of the Bank of North America, receiver of the company. The property is to be sold and distributed among the creditors.

The Fond Du Lac Street Railway Company, of Fond Du Lac, Wis., has been turned over to W. G. Curtis, who has been appointed receiver on the application of the stockholders. The Holland Trust Company holds a mortgage of $50,000 against the company to secure fifty bonds. A large amount of indebtedness is owing for construction. It is stated that there is a large holding of the company's bonds in the East.

A Telephone Patent Decision.—Commissioner Simonds, of the Patent Office, has recently rendered a decision on an application which has been pending in the Patent Office for 11 years. It is on an appeal from a decision of the Board of Examiners-in-Chief, denying patentability to the subject matter of an application for a patent for telephones filed by Daniel Drawbaugh on April 3, 1884, the same being in continuance of his original application, filed July 26, 1880, on the ground that the invention in controversy was put into public use and on sale by Thomas A. Edison and others for more than two years prior to July 26, 1880, the date of the filing of the original application.

EDUCATIONAL NOTE.

The Wells Memorial Institute, for workingmen, which is located in Boston, has recently issued its fall and winter prospectus for 1891-92. This institute conducts, during the winter, a series of free evening classes, the Lowell free lectures, an entertainment course, and a course for general information, for the benefit of the workingmen of Boston, and has a membership of nearly 2,000 workingmen, who are taking advantage of the opportunities and inducements which the institute offers for instruction and entertainment.

MISCELLANEOUS NOTES.

Scofield, Utah.—A Thomson-Houston mining locomotive, of 40 h. p., has recently been installed in the Winter Quarters mine.

Philadelphia, Pa.—A contract has been signed which provides for laying subways in four streets for underground conduits for electric wires at a cost of $28,000.

Wheeling, W. Va.—At the recent sale of the electric light bonds, the total issue of $80,000 was sold to the Bank of Wheeling at 2 per cent. premium, the city receiving thereby $1,600 over the par value of the bonds.

The Cleveland Electrical Club, recently organized at Cleveland, O., starts out with a charter membership of 25 enrolled and about 75 proposals for membership. C. W. Wasson has been chosen president; S. D. Nesmith, vice-president; J. C. O'Neil, second vice-president; H. J. Davis, secretary, and C. W. Foote, treasurer. J. R. McKinstry, S. D. Johns, with the president, secretary and treasurer, are the board of managers to whom the location of apartments has been referred.

The Johnson Company, of Johnstown, Pa., within eighteen months has purchased, it is stated, $46,000 of Thomson electric welding machines and has expended $60,000 in boilers and a plant for operating them. In referring to the experience of the company in using these machines, a recent communication from them stated that they have used one of the Thomson Electric Welding Company's machines a year for general work, and the bulk of the work done by this machine was that which could not be done by hand welding, not on account of the difficulty of the weld, but because of the general unreliability of the result. The result of a year's use of the electric welder is that the company intends to extensively adopt the machines in the works.

Industrial and Trade Notes.

The Ball & Wood Company has found it necessary to run its Elizabethport shops all night in order to keep up with its orders.

The Electric Mutual Insurance Company, of Boston, has issued an illustrated catalogue and specifications for inside hose system and water supply to protect electric stations against fire.

The Packard Electric Company, of Warren, O., has recently received an order for 2,000 lamps for parties in Winnipeg, Canada. Other orders for over 10,000 lamps have been received within a short time.

The Globe Carbon Company has removed its works to Ravenna, O. The capacity of the plant is 100,000 finished carbons per day. The new factory has all the improved appliances for the manufacture of rbons.

The Otto Gas Engine, of which Schleicher, Schumm & Co., of Philadelphia, are the engineers and builders, it is stated, has been awarded the highest diploma and gold medal for superior design and workmanship at the Strasburg (Germany) Industrial Exposition.

The Mason Regulator Company, of Boston, is sending out a neat circular by mail, the obverse side of which is for the address, the reverse bearing the following: "The latch string is always out, pull it," which being done discloses the card of the company and an invitation to visit the company's extensive works in Boston.

The Berlin Iron Bridge Company, of East Berlin, Conn., has received the contract for the new blacksmith shop building for the Dixon Manufacturing Company, of Scranton, Pa. Owing to the peculiar formation of the ground the building will be in the form of a letter L, and will be 60 feet wide by 235 feet long, constructed entirely of iron.

The Elastic Accumulator, invented and patented by Emile Reynier, of Paris, which was illustrated and described in THE ELECTRICAL WORLD a few months ago, is quite familiar to many of our readers, who will be pleased to know that this electrical invention is for sale in the United States by V. H. McRae, Room 87, Pulitzer Building, New York.

The National Conduit Manufacturing Company, of Hastings, N. Y., has recently purchased a tract of land in Denverside, the growing suburb of East St. Louis, on which it intends to erect new buildings, and remove the entire plant thereto as soon as possible. This concern, it is reported, will furnish employment to about 900 men when its new works are in full operation.

The Pond Engineering Company, of St. Louis, reports increased activity in its boiler department, particularly in electric light and power work. Recent orders for steel boilers were: from Kansas City, two; Jefferson City, two; Valparaiso, Ind., two; Waco, Tex., two; Laredo, Tex., second order; East St. Louis, Ill.; Waterloo, Ill.; Paducah, Ky.; Lawrence, Kan., and Arkadelphia, Ark.

The Electric Merchandise Company, of Chicago, reports shipments of Burton electric heaters during the past week to the following places: Salem, O.; Williamsport, Pa.; Toronto, Ontario, Can.; Oswego, N. Y.; Ottumwa, Ia.; Canton, O.; Akron, O.; Pottsville, Pa.; Troy, N. Y. Numerous orders received from points widely separated show that street railway men are adopting the latest methods of car heating.

Mr. A. A. Schoonmaker, of 158 William street, is an extensive importer of India mica, and makes a specialty of it, dealing in no other. He reports an increasing demand for it from many of the largest consumers. The extensive mica beds of India are furnishing a large supply of this valuable mineral, which is now so extensively used in the manufacture of dynamos and other electrical apparatus where a perfect insulator is wanted.

The Stearns Manufacturing Company, of Philadelphia, manufacturers of the Woodbury automatic high duty steam engines, whose manufactory is at Erie, Pa., built the two engines which are used for driving the dynamos of the electric lighting plant in the Church of Notre Dame, Montreal, a description of which was given in THE ELECTRICAL WORLD of Aug. 22, 1891, in which the engines are referred to as of the Waterbury make.

Watson & Stillman, of New York, have recently added 5,000 feet to their large hydraulic machinery works, thereby greatly facilitating the production of hydraulic tools. The output of hydraulic jacks and car wheel presses during the last two years has increased to such an extent that the adoption of this course was rendered absolutely necessary. The most encouraging reports are received as to the efficiency and superiority of this class of their manufacture.

The Washington Carbon Company, of Washington, Pa., has enlarged its plant and will from now on make a full line of carbon brushes, battery plates and carbons for arc lamps for incandescent circuits. Mr. L. B. MARKS, superintendent of the company, has made a specialty of the carbon business for some time, and is thoroughly familiar with all the requirements necessary in the manufacture of carbons for arc lamps. The capacity of the plant is 1,000,000 carbons per month.

J. J. Ryan & Co., of 68 West Monroe street, Chicago, have issued a circular calling attention to their foundry plant, which is the largest in the West and one of the largest jobbing foundries in the world, and their facilities for turning out electric castings in brass, aluminium and aluminium brass. They give especial attention to country trade, and have a large list of outside customers. With their facilities, orders received from out of town customers can be cast and shipped so as to reach their destination the next day after receipt of the patterns.

Mr. H. T. Paiste, the enterprising manufacturer of electrical specialties, of Philadelphia, owing to increasing business, has been obliged to move his factory and Eastern office from Twelfth and Market streets to the new Fuller Building, 10 South Eighteenth street, below Market, of the same city. He has taken the entire third floor of this elegant building, thereby trebling his floor space. It is the intention of Mr. Paiste to largely increase his line of specialties, which will from time to time be illustrated in THE ELECTRICAL WORLD. The Western office and store room, 341 The Rookery, Chicago, remains unchanged.

The C. & C. Electric Motor Company, of New York, is installing a 100-light dynamo for Mrs. Mary Jacobshagen, Union Sugar Plantation, La.; a 100-light dynamo for John T. Moore, Shriver, La.; two 600-light dynamos and one 300-light dynamo in the Erie County Savings Bank Building, Buffalo, N. Y.; a 200-light dynamo for John D. Muller, corner Fifth avenue and Union street, Brooklyn, N. Y.; a 100-light dynamo for the Crescent Farm Planting Association, La.; a 125-light dynamo for Shaffer Brothers, Ardoyne Sugar Plantation, La.; a 125-light dynamo for Messrs. Walbridge & Co., Buffalo, N. Y.; a 100-light dynamo for the Magnolia Plantation, La.

The Moniteur Industrielle recommends the use of a mixture of oil and graphite on all screws in machinery, stating it will effectually prevent them from becoming fixed, and protects them for years from rust, at the same time the mixture facilitates tightening up. The Joseph Dixon Crucible Company, of Jersey City, N. J., has for a number of years prepared graphite mixtures which have found great favor with machinists and steamfitters of this country. Dixon's graphite pipe joint mixture not only takes the place of red lead, but is infinitely better, while Dixon's graphited oil is used where a thinner mixture is desired and also for lubricating bearings. Graphite is regarded as the standard natural lubricant.

The "Iron-Clad" Gearless and "How to Protect Your Generators" are the captions of two descriptive illustrated pamphlets which were issued by the railway department of the Westinghouse Electric and Manufacturing Company for distribution to visitors to Pittsburgh during the convention of the American Street Railway Association. The former describes in detail the advent of the gearless motor, and referring to four illustrations states the advantages of this motor, in its construction, economy of operation, efficiency, etc. The latter refers to the causes which are liable to injure a street railway generator and states concisely and briefly the proper course to pursue in order to properly protect it. Both pamphlets contain valuable information worthy of consideration and should be in the hands of every one interested in street railway matters.

The Williames Vacuum System of Steam Heating is for sale in the United States by the Warren Webster Company, of Philadelphia, patentees, owners and manufacturers of the system. In a descriptive catalogue recently issued the features of this system are fully set forth. It consists briefly in an arrangement of apparatus for drawing the steam and condensation through the piping by suction, instead of forcing the circulation, as in previous practice, by pressure. It was first introduced by Mr. Williames in 1880 and has been in constant use ever since. The advantages claimed for the system are a saving of power, saving of coal, saving of boiler capacity, the circulation and uniform distribution of exhaust steam, etc. A large number of testimonials relative to the efficiency of the system are given in the special catalogue issued by the manufacturers.

There is no greater problem confronting steam users than that of removing and preventing scale in boilers. The most successful method employed in recent years is by the use of a non-chemical compound, the base of which is a mineral oil having a vaporizing point in excess of the highest temperature of the boiler, and which has been freed from the tar and wax found in all mineral oils. This tar, if allowed to enter the boiler, would unite with the objectionable mineral and form a putty which would settle on the sheets, tubes and flues and cause them to burn. The Pittsburgh Boiler Scale Resolvent Company, of Pittsburgh, Pa., manufactures a compound said to be very effective. It is placed in the boiler when empty, about one quart to each 50 h. p. It lightly coats the inside of the boiler, and wherever it touches no scale will adhere. The individual particles of scale forming mineral take on a greasy character from the compound, and so long as this condition continues it is impossible for them to solidify or crystallize into scale, but they will main in solution until the boiler can be emptied and washed out.

Mr. Charles K. Westbrook, manager of the isolated light and power department of the Thomson-Houston Electric Light Company, of Philadelphia, announces the following recent sales and installations of isolated apparatus, made by his department, viz.: A. B. Farquhar & Co., York, Pa., 250 incandescent; W. A. King & Co., Columbia, Pa., 100 incandescent; Wilson Female College, Chambersburg, Pa., 300 incandescent; J. K. Mosser, Allentown, Pa., 150 incandescent; Chambers Brothers & Co., Philadelphia, 250 incandescent; S. S. White Dental Manufacturing Company, Philadelphia, 300 incandescent; Shaw, Esrey & Co., Chester, Pa., 625 incandescent; G. W. Blabon & Co., Nicetown, Pa., 155 incandescent; C. H. Reiser, Philadelphia, 300 incandescent; Wanamaker & Brown, Philadelphia, 75 arc; Bethlehem Iron Company, Bethlehem, Pa., 50 arc; Baltimore & Ohio Railroad Company, Baltimore, Md., 50 arc; Pennsylvania Railroad Company, Altoona, Pa., 50 arc; William Sellers & Co., incorporated, Philadelphia, 35 arc; Tyrone Iron Company, Tyrone, Pa., 18 arc; Norristown Steel Company, Norristown, Pa., 9 arc; Pencoyd Iron Company, Pencoyd, Pa., D 30 generator; Girard Estate for Burk & McFetridge, Philadelphia, 7½-h. p. motor.

The Crocker-Wheeler Electric Motor Company, of New York, has just issued a revised and extended catalogue. It is an interesting pamphlet of over 50 pages. To those seeking information regarding the electric motor and its numerous applications it will prove of great value. The text, which is profusedly illustrated, discusses at length the construction of the Crocker-Wheeler motors, and their special features, with convenient and valuable tables of dimensions, etc. There are also directions for setting up, connecting and running these motors. An interesting chapter on "Windings" engages the attention, also a table of sizes and types of motors manufactured for constant potential circuits. The fireproof starting, regulating and reversing boxes made by the Crocker-Wheeler Motor Company are described, and considerable space is given to their small motors, 1-6, 1-8 and 1-12 h. p., together with their application to electric fans, electric pumps, etc. The arc circuit or constant current motors, Crocker-Wheeler type, are fully described and illustrated. The pamphlet also describes "A visit to the Crocker-Wheeler Electric Motor Company's factory," and an interesting paper on "Cost of Electric Power—Comparative Efficiency of Large and Small Motors," by Dr. S. S. Wheeler.

Business Notices.

Battery Cut-Out, Cheap.—Sensitive, reliable, never requires attention. Gas lighting much improved by its use. Electric Supply Company, of 105 South Warren street, Syracuse, N. Y.

Vestibuled Combination Cars.—The latest addition to the matchless equipment of the Chicago & Alton Railroad comes in the form of combination smoking and day cars. These cars are divided into two parts, one half being given up to smokers, while the other half is devoted to regular passengers. They are vestibuled, heated by Baker's patent safety car heater, and contain all modern appliances, which in every way contribute to the comfort of the passenger. In the new cars a marked improvement over the old fashioned straight-backed car seat has been made, the backs in the new cars being very much like those found in the chairs of the Alton's famous reclining chair car. Combination cars, palace reclining chair cars (free of extra charge), Pullman sleeping cars and dining cars will now compose the equipment of the Alton's famous Chicago-Kansas City-Denver vestibuled limited trains, while the night trains between St. Louis and Kansas City will be made up of combination cars, palace reclining chair cars (free of extra charge), Pullman palace sleeping cars, and day cars, the entire train being vestibuled. In matter of equipment the Chicago & Alton Railroad leads all leaders.

The Chicago, Milwaukee & St. Paul Railway Company's 6,150 miles of road traverses a vast territory, rich in all the resources that insure industrial success. The industrial department is conversant with the iron, coal, lumber and tanbark; the water power (both river and artesian) for factory and electric power purposes, the markets, the transportation and financial facilities, and other interests on the line pertaining to industrial development, and disseminates information concerning same. A number of new factories have been induced to locate—largely through the instrumentality of this company—at enterprising towns on its lines. As the interest of the company is to secure the location of industries at places where the surroundings will insure their permanent success, the information furnished a particular industry is pertinent and reliable. In the Eastern States and in other parts of the world factories are so congested and distant from the actual market as to result in fierce and destructive competition. That the West is taking a place as one of the great manufacturing territories of the world is forcibly impressing itself upon discerning and enterprising manufacturers. Steps should be taken by such while the field is as yet not fully covered, and while inducements are still being offered, to locate in the West. Individuals or companies wishing to embark capital in Western industry can find a profitable field. For particulars relative to industrial advantages on the line, address Luis Jackson, Industrial Commissioner, C., M. & St. P. Ry., 160 Adams St., Chicago, Ill.